POWER

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"As a Man Thinketh, So is He"

WHAT is it that makes the difference between men? Physically, we are all the same combination of ham and eggs and fish cakes and pie, and the physiologists say that our bodies change every seven years; but that indefinable quality of self that looks out of a man's eyes, that his friends love and his enemies hate and fear, that makes men listen when he talks and come to him with their troubles or treat him as a nonentity, that makes some men command and others obey—what makes this difference in men?

During every conscious moment one's mind is busy about something. There was the old Yankee who said, "Sometimes I set and think, and sometimes I just set"; and there *is* a difference between ordered, systematic thinking and opening up the floodgates and letting the scatter-brained thoughts flow through. It is true, too, that it seems to hurt some men to really think. Nevertheless, one must be always thinking of something, and it is the way his mind is used and trained, what is going on in one's head as he walks the streets or rides the trains, as well as when he sits down to do real brain work, that makes him what he is.

Are one's thoughts frivolous and trivial, such as he would be ashamed to have to show if the lid were lifted from his brain? It will show in his stolid face, in his furtive bearing, as well as in his inability to advance thoughts that one is glad to listen to. Is he soured with the world? Does he see the evil, the injustice, the imposition without any apparent appreciation of the good that life offers or any intelligent, constructive suggestion for the betterment of the subjects of his continual grouch; or does he admire the roses which hide the thorns and see and approve and commend the good, and avail himself of the opportunities that offer? Is he always scheming to "get hunk" with somebody or to gain a personal advantage, or is he looking for chances to make somebody happy and the world a better place to live in? Are his thoughts such as will make him more useful and fit him for greater responsibilities in his vocation and his relations with his fellow men?

One's thinking is under his own direction. He can make of it what he will, and "As a man thinketh, so is he."

F. R. LOW.

Dirt Plus Static as Cause of Turbo-Generater Fires

By D. D. HIGGINS
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Dirt deposits in generator windings. Description and results of test made to ignite dirt with a static spark. Trouble caused in generator winding due to presence of dirt. Prevention of precipitation from cooling air on generator windings.

ARMATURE coils of large turbo-generators usually are not accessible for frequent cleaning, and owing to the great quantity of air required for cooling, a deposit of dirt develops. The weight of the air passing through a 35,000-kw., horizontal, high-speed turbo-generator each hour is approximately equal to the total weight of the unit itself. The amount of solid matter carried in suspension in the air into the generator depends on the location of the power station, whether or not air washers are used and also where the air washers are located with reference to the generator air intake.

In those installations where little dirt or coal dust gets into the generator, owing to the proper installation of an air washer, the machine windings will remain clean for two or three years. But where the washer is at some distance from the generator air intake, more or less coal dust, oil vapor and miscellaneous power-station dust will be deposited in the pockets of the armature and field structure, in the small spaces between the end turns of the armature, between the backs of the coils and the anchor rings, in all the air passages and also on the surfaces of the coils directly in line with the highest-velocity air. This seems strange, for one would expect that the light dust would be carried easily over clean varnished surfaces and find lodgment difficult owing to the high velocity of the air in the constricted passages.

Dust Leaks From Outside Into Air Duct

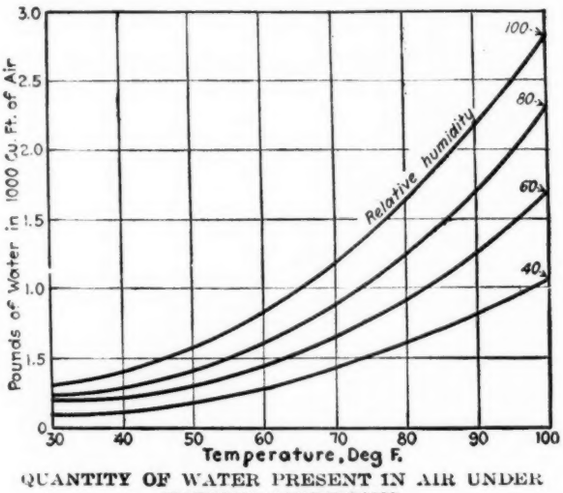
The foregoing refers to cases where the fans are located on the generator rotor. Consequently, the air line is under suction, and as the ducts are not inclosed and shut off from the plant through which they pass, more or less dust is drawn in through cracks or the joints in the ducts. It would be good practice to locate the ducts in a compartment shut off from the rest of the power plant, thus giving little opportunity for dust and oil vapors to be drawn into the air duct.

Owing to the inaccessibility of the generator parts for routine inspection, they usually are not cleaned except when the unit is taken out of service for the annual inspection and overhauling, unless the operating temperature rises owing to the stoppage of ventilating ducts and becomes excessive.

Dirt on the high-voltage coils of the generator, therefore, attracts attention and has given rise to considerable speculation as to what part it has played in generator burn-outs. From widely separated points cases have been reported of generators being burned out during the winter months when the internal temperatures were low and the load only normal. No definite diagnosis could be made.

Knowing that there is a possibility of static electricity accumulating on the windings of generators operating at voltages around 9,000 to 13,000, the writer has investigated the insulating and combustible characteristics of the dirt that ordinarily collects on such windings, to determine, if possible, whether such dirt could be ignited by static. Four representative samples of the dirt, which seemed to differ somewhat in color and weight, were collected from the windings. All these samples readily ignited from a match flame and burned without a flame after a small amount of gas had been distilled off and burned. The material burned like punk and was difficult to extinguish. The odor emitted did not resemble coal gas, as had been anticipated, but was more like that of smoke from burning oil.

In the samples neither oil nor coal dust was visible, although one was dead black and the others were a little lighter in color. If oil did exist, it was in small quantity, because the dirt was in powder form although it could be readily packed. No visible oil was present in the generator. The dirt was easily ingited by a hot



QUANTITY OF WATER PRESENT IN AIR UNDER VARIOUS CONDITIONS

static spark about ½ in. long and yellow-white; a blue spark would not ignite it.

Only a crude condenser was available from which to obtain the spark, and it was not safe to make close observations. Nevertheless, the device used closely approximated a working conductor in a generator armature. It consisted of a length of high-voltage single-conductor rubber-and-tape-insulated cable connected at one end to a grounded test transformer, while the other end was free. For a couple of feet on the outside of the cambric covering of the cable asbestos tape was applied and coated with asphaltum paint. The idea was to produce a static spark similar to what might exist in a generator.

The dirt was put on the concrete floor and brought to within about ⅛ in. of the cable. The static field that surrounded the spark seemed to have the effect of fanning the fire, once it had started, and it was not at all difficult to obtain a ball of burning dirt ½ in. in diameter resembling charcoal and giving off intense heat. The static field also attracted particles from the burning dirt for momentary contact with the cable, where

they would become charged with like polarity and then be quickly repelled. These repelled sparks would travel six or eight inches and, if conditions were favorable, might start other fires.

When cold the dirt was an excellent insulator. A strip of it 2 in. long on a testing table withstood 30,000 volts, at which point the air surrounding it broke down; that is, the dirt was a better insulator than the air. An eighth inch of dust repeatedly withstood 2,400 volts. When the dirt was warmed a little, its resistance dropped; in fact, it became a fairly good conductor, a strip $\frac{1}{8}$ in. long would break down quickly at 2,400 volts. In this respect the dirt seemed to have the negative temperature coefficient peculiar to carbon.

Tests Made With Direct-Current

When a pair of direct-current test leads with 110 volts between them and the circuit arranged so as to limit the current to five amperes, were put in contact and buried in the dirt and then separated, the small resulting arc would instantly set fire to the dirt, which would burn brilliantly, something like a flame arc lamp, although the leads were separated nearly an inch. It would appear from these results that under favorable conditions static may set fire to the windings, but that the presence of the dirt on the windings does not necessarily involve a hazard so long as the temperature is about normal and the static is not concentrated into a spark.

Where air washers are used continously the year around, the humidity of the cooling air should be around 95 per cent, so that there will be enough moisture coming in contact with the surfaces of the windings to lower the surface resistance to ground and thereby allow the static to drain off uniformly and not collect. If it does collect, it will begin to discharge at the weakest point in a concentrated form or spark, which may ignite dry dirt.

In cold weather and without air washers the humidity will average around 50 per cent and static is liable to pile up on the windings and armature leads. The weakest part of high-voltage windings is in the end turns, because it is impossible to lay the tape as evenly and as tightly on the curved or bent portions of the coils as it is on the straight sections in the slots. Also, there is considerable hand taping done on the coil connections after the coils are joined and soldered.

Where Most Dirt Collects

It is in the end turns that most of the dirt collects, and as they do not come in as intimate contact with the frame or grounded parts of the armature, static is more likely to become concentrated and leak off through the dirt and ignite it. Also, as the insulation is weakest in this portion of the winding, the presence of a low-resistance dirt path that has been heated by a static spark imposes an abnormal strain on the armature at a point where it can stand the least. What has been said about dirt, static and moisture, in connection with generator windings, also applies to air-cooled transformers.

High-voltage single-phase generator cables, whether lead- or cambric-covered, should in general be insulated carefully at all points to avoid trouble from static and sheath currents. Long runs of 100 ft. or more are common for such cables, and when they are cambric-covered, the supporting insulators should have considerable surface and be accessible readily for frequent cleaning. Such cables, if lead-covered, should be grounded every 50 ft., through a high resistance, something like 600 or 800 ohms, to drain off any static that may tend to accumulate. The high-resistance grounds will prevent the circulation of troublesome current by the induced voltage in the sheath.

In generators the presence of dirt is quite likely to cause trouble other than overheating, breakdown by static, etc., as mentioned in the foregoing. At times of severe short circuits in the high-voltage feeders, the magnetic circuits of the generator armature and field and their clamping frames undergo great and sudden changes of flux. Changes of flux of such magnitude produce voltages and consequently currents in all parts constituting closed metallic circuits. Where low-resistance, closed circuits exist, there is no particular hazard, but where there is a relatively high resistance point in such a circuit, the "point" may be instantly brought to an incandescent heat. This spark will last only for a fraction of a second, but may be sufficient to ignite combustible dirt, and in turn cause the generator to break down and be burned out. Such stray currents and voltages are similar to those occurring in transformer cores and frames at the instant of switching the transformer onto a source of supply. At times of short-circuit on the armature the field winding and entire field structure of an alternator becomes the short-circuited secondary of a transformer.

Value of Air-Washer Installations

Air washers are of considerable value in generator installations, provided they are properly installed and intelligently operated, but become a hazard when neglected, particularly in cold weather. At such times it is necessary to mix some air from indoors with that entering the washers from outside the building, in order to keep frost and ice from forming on the eliminator plates and screen. This will occur if the air entering the washer falls much below 35 deg. F.

When mixing quantities of air of different temperatures and humidities, the resulting mixture may contain considerable water vapor or fog—that is, the humidity may be 100 per cent—and when such a mixture comes in contact with anything of slightly lower temperature, precipitation occurs.

Frequently, generators are shut down during the night when the load is light and have a chance to cool off. When again started, they may be a few degrees colder than the air supplied them, and if the humidity is high, precipitation and accumulation of water may occur at inaccessible and unobservable points. Needless to say, this is one of the most serious conditions that can exist.

Generally speaking, there is small likelihood of moisture and static troubles when the cooling air is free from fog. If the temperature of the air entering the generator is much below that of the turbine room, condensation will occur on the external sides of the generator casings and may be drawn into the armature through cracks or find its way down onto the terminal connections and cables. To illustrate these conditions, assume the air entering the generator to be at 80 deg. F. and 80 per cent humidity. As shown in the accompanying chart, if this air is lowered in temperature only 8 deg. F., the humidity will be 100 per cent and any further reduction in temperature, such as might occur when the air comes in contact with a cold armature winding or frame, will cause precipitation.

Electric Motors for Driving Refrigeration Plants—Their Types, Characteristics and Selection

By W. H. MOTZ

IN THE selection of a suitable method for driving refrigeration plants the local conditions must be given thorough consideration. In many localities the cost of fuel for power purposes is high or the delivery unreliable, and electric motors are favored on account of lower power cost per ton of refrigeration. Another economic consideration favoring the installation of electric motors is that this method of driving has a comparatively high efficiency and the efficiency remains high at decreased loads. The first cost of the electrically driven plant is frequently lower than that of a steam plant, and this, in many instances, dictates the choice of electric drive. Furthermore, the total cost of power in the electrically driven plant will probably be less on account of the fact that less labor and a smaller amount of space are required and overhead charges are somewhat lower.

The advent of the raw-water ice-making system in 1909 gave a great impetus to the application of electricity in refrigerating plants. Since distilled water is not essential, the compressors, as well as the auxiliaries, can be operated with electric motors. Likewise, since the electrically driven plant does not require to be near a railroad in order to receive its fuel supply, it may be located in any convenient place near the center of the distribution territory. This reduces very materially the delivery expense of the ice.

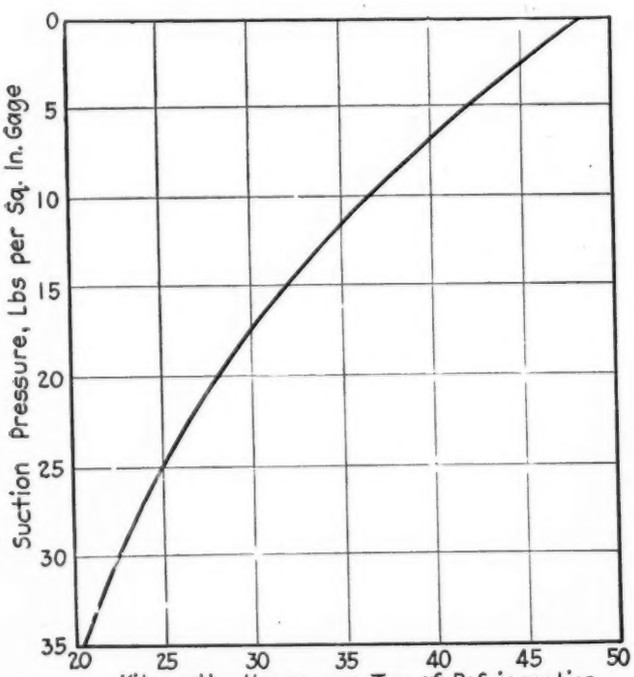


FIG. 1. ELECTRIC CONSUMPTION PER TON REFRIGERATION

An additional consideration in favor of the electric drive is that the electric motors in refrigerating and ice plants are considered a desirable load for the central station. This is due to the fact that this kind of electrical load can be arranged so as to produce a more desirable and uniform total load on the central station. The usual plant can decrease its power requirements during the central-station peak load, enabling a low electric rate to be secured.

Reliability of Electric Drive

The increasing popularity of the electric drive is in no small measure due to the reliability of the operation, which is based upon two fundamental factors. In the first place, the engine and boiler in the refrigerating plant are more subject to mishap and shutdown than is the compressor. In the second place, the electric motor is very dependable, being one of the most sturdy, practical and trouble-proof pieces of apparatus in the power plant.

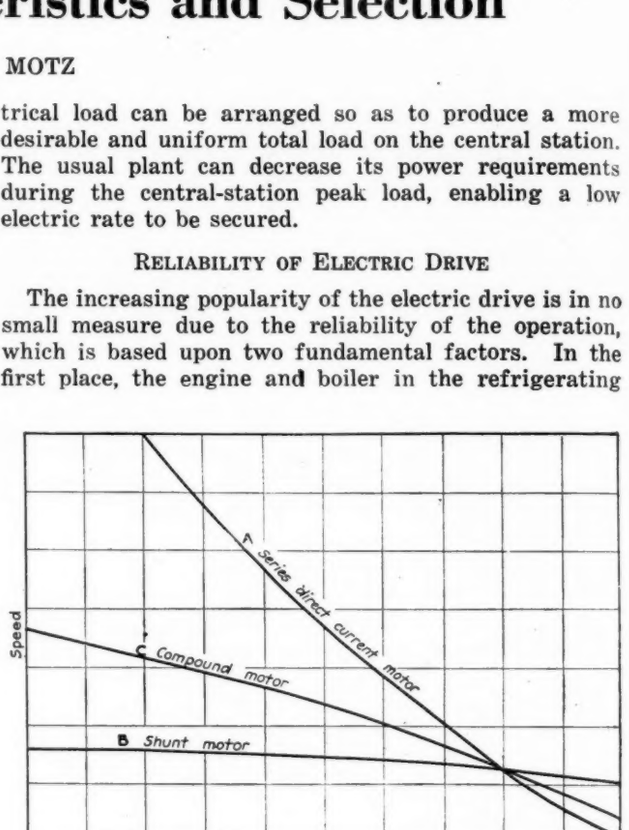


FIG. 2. SPEED-TORQUE CHARACTERISTICS OF DIRECT-CURRENT MOTORS

Of course the motors must be installed properly and they must receive attention and proper lubrication. In the case of power transmission by belting, the belt wheels, motor pulleys and belts must be properly designed to eliminate flipping, etc.

The electrically driven plant requires the minimum amount of attendance, and the operator does not have to be as high grade as is required for the efficient operation of steam units. The electrically driven plant is virtually automatic as long as there is continuity in the central station service.

Flexibility of Operation

Flexibility of operation is easily obtained in the electrically driven refrigerating plant when it has been properly designed. In the first place, electricity readily lends itself to the subdivided power plant. Thus several units of about the same size may be installed in a given plant and the magnitude of the refrigeration load at any hour will determine the number of these units to be operated. In the electrically driven plant it may be feasible to install, in addition to the main units, a small compressor to pump out any part of the system or to

furnish the refrigeration in the winter months, thus allowing the main units to be shut down. The flexibility of the operation of the auxiliary apparatus is one that does not ordinarily receive the proper attention. The selection of the auxiliaries with considerations as to their economies from one-half to full load is important, as well as their practical arrangement in the plant. The correct number of auxiliaries is advocated for each plant. It is obvious that the auxiliaries should be directly connected to their respective motors wherever possible.

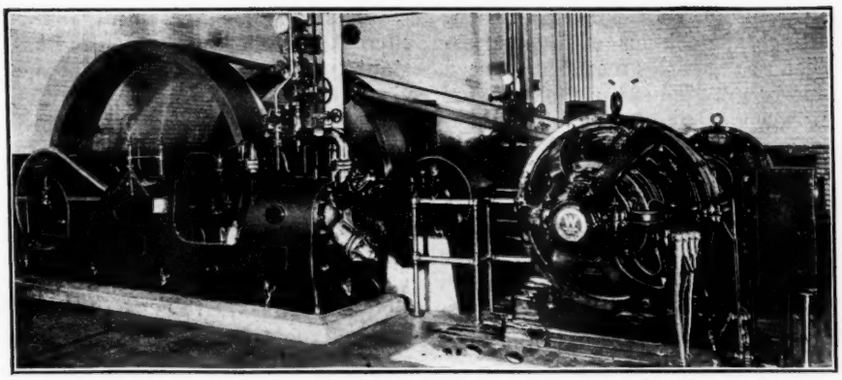


FIG. 3. COMPOUND-WOUND DIRECT-CURRENT MOTOR DRIVING COMPRESSOR

Economy of Operation

The power that is required to drive an ammonia compressor depends upon a number of factors, among which the following are probably the most important: The ammonia working pressures, the type of compressor and motor, the relative size of motor, and the method of power transmission. Generally speaking, it may be said that the average electrically driven plant has a comparatively low consumption rate in B.t.u. per ton of refrigeration. This is probably due to the fact that the actual generation of power in the average refrigeration plant using its own generation machinery is not efficient, while, on the other hand, the central electrical stations have comparatively high efficiencies, and the transmission and utilization of the electrical energy is accomplished in an economical manner. This, however, does not apply to the many steam-driven refrigerating plants equipped with modern condensing engines giving a very high economy. Since the ammonia working pressure determines to a very large degree the amount of power that is required, Fig. 1 has been prepared to show graphically the variation of the power required to operate the compressors at the different suction pressures and at an average condenser pressure of 170 lb. per sq. in. gage. Average operating efficiencies were assumed. This chart shows the power that is consumed by the mechanical compression of the vapor alone and does not include any allowance for the usual auxiliaries of the plants. Under the ordinary conditions the power required to operate the auxiliaries tends to become abnormally high. In the larger plants it is advisable to install an electric meter to measure the current consumed by the compressors, while a separate meter should be used to indicate the current consumption of the motors which drive the auxiliaries.

The effect of the load factor upon the economy of operation is a very important consideration. The economy of operation decreases as the load factor is lowered. The load factor is improved by installing subdivided power units, by providing storage capacity, by operating continuously, etc.

The Selection of a Suitable Motor

The correct application of electric motors to refrigeration plants depends upon a number of factors, among which the following may be considered important: The operating characteristics of the motors, the type of refrigeration plant and the capacity of the plant. Among the operating characteristics of the motors the speed-torque considerations are probably the most important. In general it will be noted that the local conditions will make each plant a particular problem in itself, so that no specific rules may be given. Therefore, only the general considerations of the types and characteristics of the electric motors will be given. One of the most important factors in the selection of a type of motor for a certain kind of work is the variation of speed as the load on the motor is varied. Fig. 2 indicates the speed-torque characteristics of the common

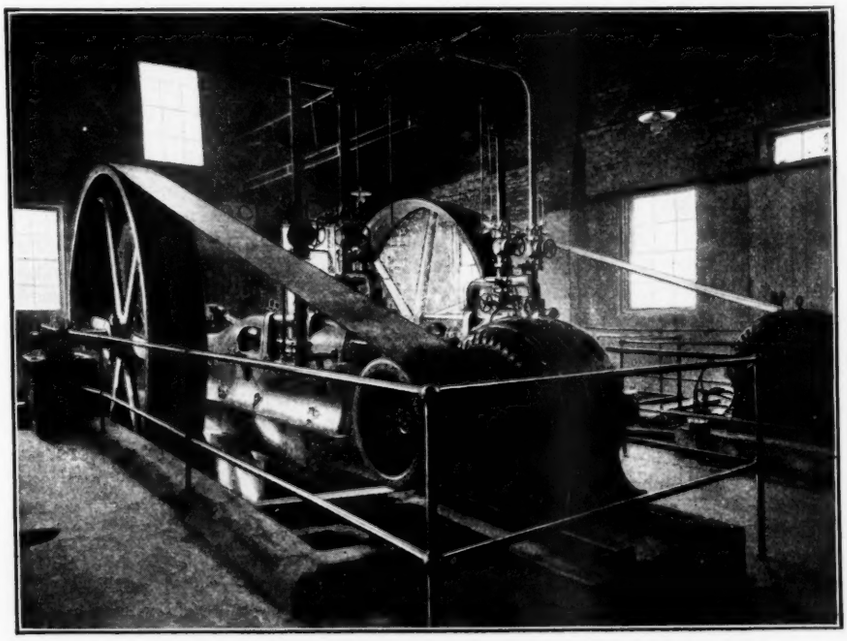


FIG. 4. ONE-HUNDRED-FIFTEEN-HORSEPOWER INDUCTION MOTOR DRIVING COMPRESSORS

types of direct-current motors. In this figure the curve *A* represents the characteristics of the series-wound motor. The speed of the series motor is reduced greatly as the load is increased. Thus the series motor will develop almost any torque that is demanded, but a reduction of speed is brought about. This type of motor is well adapted to hard service where constant speed is not necessary. However, on light loads it speeds up rapidly so that an unsafe speed is attained in a few seconds. Therefore, it is necessary to have this type of motor connected positively to its load and under manual control at all times in order to avoid possibilities of excessively high speeds. It is adapted to variable-speed service and in the refrigeration plants is used principally to propel electric cranes and to drive electric hoists.

The curve *B* in Fig. 2 indicates the speed-torque, or speed-load characteristics of the shunt-wound direct-current motor. An inspection of this curve will indicate that the shunt motor may be used for constant-speed service, since it maintains approximately constant speed for all reasonable loads. The no-load speed is definite and only slightly higher than full-load speed. The shunt motor is used to drive ammonia compressors in sizes up to 40 or 50 hp. For this service proper commutation may be secured by using commutating pole windings. The ordinary shunt-wound motor is often employed to drive brine agitators, centrifugal pumps, blowers and the like, where the necessity of commutating poles does not exist.

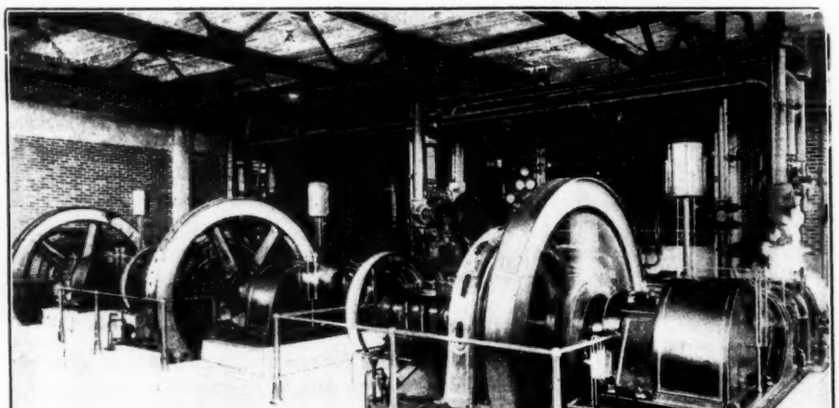


FIG. 5. COMPRESSORS DIRECT-CONNECTED TO SYNCHRONOUS MOTORS

The Compound Motor

The speed-torque characteristic of the compound-wound motor is indicated by curve *C* in Fig. 2. The speed is approximately constant at various loads, the free speed being considerably higher than the full-load speed. Moderately heavy overloads can be carried with ease, and a fairly large starting torque is developed. It is apparent that the compound-wound direct-current motor, possessing good operating characteristics, is well suited for plants where direct current is available. It will be noted that the speed variation with change of load in the compound motor is greater than that in the shunt-wound motor and less than that in the series motor. Again, the starting torque is greater than that of the shunt motor, but it is less than that of the series motor.

The compound-wound direct-current motors are used in refrigerating plants to drive ammonia compressors, reciprocating brine and water pumps. Fig. 3 shows two 13½ x 24-in. ammonia compressors belted to 150-hp. direct-current compound motors operating at 450 r.p.m.

Generally speaking, it may be said that alternating-current polyphase induction motors are inherently constant-speed machines. Several methods have been devised to vary the speed of induction motors for a given output, but none of these methods has been entirely successful and practical. The speed falls off only slightly as the load is increased, the decrease from no load to full load being less than 10 per cent of synchronous speed. The squirrel-cage induction motor has a comparatively small starting torque, while on the other hand the starting current is quite large. The power factor of the starting current is low, and since the starting current is large, heavy fluctuations of the voltages of the supply line are induced. However, this type of motor has the advantages of being simple and strong in construction.

In refrigeration plants this type is used in sizes of 25 hp. and less for driving centrifugal pumps and the like. The starting torque of the slip-ring alternating-current motor is large and the starting current is not excessive. Ordinarily, the starting current for full-load torque is approximately three times the full-load current, and the starting torque one and one-half times the full-load torque. Thus the slip-ring motor is particularly well adapted to starting heavy loads with the minimum amount of current. However, heavy overloads should not be carried, since these will produce too much slip between the speed of the motor and the revolving magnetic field, thereby stalling the motor. The starting of these motors is accomplished by means of external resistance.

This type is generally used in sizes from 25 to 150 hp. for driving ammonia compressors and other machinery. Smaller sizes are well adapted to drive plunger pumps, cranes and the like. Fig. 4 shows two 13½ x 24-in. horizontal ammonia compressors which are each driven by a 115-hp. 440-volt three-phase 60-cycle slip-ring induction motor operating at 495 r.p.m.

Synchronous Motors

At present there is a tendency toward the extensive use of synchronous motors to drive both slow-speed and high-speed ammonia compressors. Motors of this type are often belted to the slow-speed ammonia compressors, but are more generally directly connected to high-speed compressors. The starting torque is comparatively low, being approximately one-third of the full-load torque. They are not inherently self-starting and are started really as induction motors. On the other hand, when they are at synchronous speed they can carry heavy overloads for short intervals.

The advantages of using synchronous motors directly

connected to ammonia compressors should be obvious. The directly connected unit is simple and compact, occupying the minimum amount of space. The expensive belt is eliminated. The motor requires no base, pulley or bearings, since it is mounted directly on the compressor shaft. The rotor of the motor acts as a flywheel so that the compressor flywheel may be somewhat lighter than usual.

It is also true that this type of motor has a high efficiency. This is quite noticeable when compared to induction motors at the lower speeds. They operate at a high power factor, and consequently a lower electrical rate is usually given plants having synchronous motors.

This type should generally be used for driving compressors when the horsepower requirements are above 150. The present tendency is to use synchronous motors directly connected to high-speed ammonia compressors. Its one drawback which is shared by all alternating-current motors, is the impossibility of securing speed variation; the compressor must be operated at constant speed at all loads.

Modern Factory Processes Applied to Boiler-Room Operation

BY T. A. MARSH
Chief Engineer, Green Engineering Company

IN 1921 factory executives have been turning to a detail study of their power plants. During the last few years they have had no time for such study. The cry has been for more and more of the factory product regardless of small savings—the buyer would pay any price within reason if his needs were met. Dividends depended almost entirely upon production, and executives became production experts. The possible saving of 1 or 2 per cent in the company coal bill, amounting to a few thousand dollars, was of little interest. These small amounts were considered negligible beside production figures running into millions, and the executive gave his entire time to the millions.

This year these executives have been confronted with a different problem. The demand for their products is limited. The buyers are discriminating in favor of the lowest prices. Competition is keen. It is vital to make every saving, for savings are now considered in terms of dividends. So executives are turning to the boiler rooms and power plants, which they have so long neglected.

Plants are Suffering from Neglect

In most cases they are finding lack of scientific study and want of organization. They are finding one department of their factory that has suffered and is still suffering from neglects, both monetary and mental. Operating engineers, who have been depended upon for results, have been unable to solve their problems because of insufficient understanding and no co-operation on the part of their executives. There has been little demand for better equipment and methods for determining steam costs, and steam-production costs are still crude. In some cases the practice of securing an occasional report from consulting engineers is the only real assistance given by the management to the operating men. In other plants a general conference on power costs is the accepted means of checking the equipment. An occasional report from an outside organization or a general conference on the power-plant situation, no doubt, corrects defective points, thereby helping the general situation.

Confronted with the task of going into situations such as these and literally saving this year's company dividends out of former operating costs, executives are coming to look upon the boiler room as they would any other department in their factory. They look upon steam as the manufactured product of this department and upon the processes that are carried on for the manufacture of steam as purely repetitive as the processes found in any of the other departments of the factory. In other words, they discover that they are operating a steam factory devoted to the quantity production of steam.

Coal going into this factory is the raw material. Losses of this coal in the ashpit, to these executives, form the scrap heap of their new found factory. Boilers, superheaters, the stokers and all other equipment to them are so many items of machinery that must be made to stand up and perform under a quantity-production program in the same way that screw machines, triphammers and other equipment perform in other departments.

Stoker and Furnace Should Be Studied

Of all the equipment going into this steam factory, none offers more room for study in application than do the stoker and furnace. It is generally recognized that there is no one best stoker that is applicable to all situations. No single furnace design can be universally applied. In each case where a stoker and furnace are to be placed under a boiler, the engineering problem is deserving of all the experience and intelligence that can be brought to bear, for in these two elements of the steam-factory equipment lie the greatest possibilities for losses or gains in actual operation.

In selecting the furnace and stoker design, the executive must first realize that he has a variety of equipment to choose from. Much of this equipment is backed by years of study and application, all of which is concentrated in the selling mechanism of the purveying organization. He must realize that he has before him several different conceptions of the right piece of apparatus and design and that his task is to select the right one for his particular performance.

As in the case of factory machinery of other kinds, the executive must first satisfy himself that he is dealing with manufacturers who, because of the longevity of their organizations, know what they are talking about. Their experience and integrity, he will find if he purchases from them, are the best insurance of performance he can secure. Having satisfied himself on this point, he is then concerned with the three following general points:

1. Design of and material used in the stoker and furnace offered.

2. Possible maintenance of stoker and furnace when operating under his particular load conditions.

3. All the phases of performance of each particular stoker and furnace under his load conditions.

Design is the most important factor to be considered. On right design rests not only the most important results of the installation—the production of sufficient steam—but design also controls almost every item of maintenance and performance.

Designing the Stoker and Furnace

The stoker and furnace must be designed so that the performance will be flexible enough to meet every whim and turn of the load demand placed upon the boiler. The problem is not one merely of burning coal. It is one of producing steam as it is required, whether in peaks or long, steady overloads or loafing along at boiler rating. Operation at low ratings economically, when the load is low, is just as important to the modern executive as the carrying of peaks or sustained overloads.

Few executives control the source of their coal supply for any continued period of time. In stokers they are talking of equipment that lasts 15, 20 and often 25 years. Then the next most important item to be considered is that of adaptability to the coal supply. The stoker equipment selected must be able to burn successfully the cheapest coal available on a cost per B.t.u. basis and at the same time be ready to burn successfully less desirable coals if it becomes necessary.

One division of the adaptability element worthy of serious consideration is the meeting of the labor market. You cannot get teamsters to drive oxen these days, nor can you get help to run boiler rooms if the job means that they are to spend half their time in the ashpits and the other half repairing the interiors of half-cooled furnaces. Then the stoker and furnace must be adaptable to the labor market as well as to the coal supply. With a stoker as flexible as the load demands, adaptable to the coals and labor markets, made of standard strength and material for the class of work involved, the equipment should next be examined for maintenance.

Efficiency Neglected During War Period

During the war period maintenance did not count for much. It was permitted to mount unnoticed so long as the equipment delivered the steam required. Dividends then depended upon the quantities produced, not upon net efficiency in operation. New equipment must indicate that it will require few repairs. Repairs are costly for the making and more costly for the time they throw whole units out of commission. Time is costly in a boiler room, or steam factory. If the design is right, there will be the least possible maintenance on the furnace and arches under the load conditions; if the material is right, there will be the least possible maintenance on the stoker. However, the stoker has wearing parts, and the modern executive is demanding that it be so constructed that all repairs may be easily and quickly made.

Since the executive is looking for savings, he is much interested in the possible performance of the equipment he is contemplating, for performance has many sides and is the ultimate answer to his problem. He must make sure that this answer is the correct one. Under performance the executive is first interested in what it costs to make his equipment perform. He is interested in net efficiency. He cannot purchase equipment that will deliver high efficiencies if he must take from 5 to 10 per cent of the steam produced to operate his stokers and other auxiliaries. He is seeking that stoker which will deliver the highest net efficiency.

Cost of Labor to Operate

The next cost to be considered is that of labor to operate. This cost is tied in with the question of automatism. From his factory experience the executive is seeking the most nearly automatic machinery, provided it will deliver the same net efficiency or better.

Stoker equipment must be so designed as to prevent the formation of clinker, or if it will not prevent the formation, it must provide for the removal of clinker from the furnace without shutting down the boiler or losing the service. Boiler time on the line means money, and inversely, every time a boiler is forced off the line a piece of productive machinery is made idle. Modern factory practice demands that this idle time be held to a minimum.

From experience the factory executive will probably begin a search for that loss in his steam factory which corresponds to the scrap pile in his other departments. He will find it in his ash pile. His raw material is coal. With some stoker equipment he will find, upon analysis, that from 2 to 10 per cent of his raw material goes to utter loss in his ashpits. The saving of 2 per cent of his coal bill by cutting down these ashpit losses may mean considerable when applied to company dividends in the years to come.

The application of these standards to stoker and furnace equipment has brought new standards into the study of combustion, lifted the problems from the purely engineering and placed them on a financial or economic basis. Manufacturers of stoker and furnace equipment are building their products, not to excel in any one engineering point, but to deliver the highest net efficiency at the lowest possible cost and to make this delivery under the quantity-production standards that are now being applied to the steam factory—the boiler room.

The July 15 issue of the *United States Commerce Report* published a table showing the rent of dwellings and prices for gas and electric heating in 55 German cities in January, 1921. The following results for the City of Berlin are not far from the average and therefore give an idea of living expenses in Germany:

AVERAGE RATES IN BERLIN IN JANUARY, 1921

	Marks
Monthly Rent:	
Two rooms and kitchen	51
Three rooms and kitchen	77
Four rooms and kitchen	104
Rate for gas per cubic meter	1.25
Rate for electricity per kilowatt-hour	2.00

The gas rate of 1.25 marks per cubic meter is equivalent to 35 marks per thousand cubic feet.

On the basis of the pre-war rate of exchange of 25 cents per mark these prices would appear high for gas and electricity, but not very high for dwellings by comparison with American standards. The value of the mark on January 1 was about 1.35 cents, at which rate the rent for the average home of four rooms and kitchen in Berlin amounts to the ridiculously low sum of $1.40 per month. Even when allowance is made for the fact that wages (figured in dollars) are low, it seems safe to conclude that the Berlin tenant gets off very easily so far as rent is concerned.

The DAM and Its APPURTENANCES

By N. L. Devendorf*

ALMOST every hydro-electric plant has a dam of some sort as an integral and essential part of the development. It may be a great and costly structure of cyclopean masonry built across a valley, or a little diverting dam three or four feet high to collect the meager dry-season flow of a mountain stream and turn it into a ditch or flume, or almost any sort of structure between these extremes. The design of dams and their construction are beyond the scope of this article, but it may be permissible to say that a dam is subject to forces and stresses somewhat different from those met with in other structures, and which make skillful and careful design and sound construction imperative necessities. Water is a fluid and has no stability in itself, but will flow, and continue to flow until it finds its level or is stopped by some solid barrier. This is the purpose of the dam—to hold back enough water to create a head the pressure of which can be utilized as mechanical energy.

In the building up of this source of power there are stresses due to the weight or hydrostatic pressure of the water, which are exerted downward and outward, so the bottom on which the water rests must be sound and the dam, besides being impervious, must have sufficient mass and weight to enable it to withstand the constant pressure without danger of slipping, cracking or overturning.

There are a number of points in connection with the various types of dam regarding which the operator should be informed. Some of these will be outlined briefly, as they are necessary to the intelligent, safe and efficient handling of the property.

The earth-embankment dam is commonly used for low-head development in the less hilly parts of the country. If well built and provided with sufficient spillway capacity to give a large factor of safety in the handling of floods, this form of construction is probably as stable and permanent as any other, under the conditions of earth foundation and low head, for which it is best adapted. It is necessary that the water be kept well below the top of the embankment, as a small overflow, if not checked immediately, will increase rapidly and will soon cause serious erosion of the embankment, with perhaps disastrous results, not only to the dam, but possibly to persons and property downstream. Erosion from rains and perforation of the embankment by burrowing animals or other cause likewise must be prevented. The concrete core-wall generally built in the dam is the best insurance against perforation, and a strong sod of some rank and heavily rooted grass will diminish the erosion from rains.

Of an earth dam the spillway section may be of any type, but in a comparatively flat country, where the freeboard of the pond is low, the spill is usually controlled by means of some sort of movable crest. The spillway is generally of concrete, with a "tumble basin" below, to break up as much as possible the force of the discharged water. Beyond the tumble basin is an apron of concrete or timber, and if the bottom is soft, this apron may be extended some distance downstream, to prevent backwash and erosion.

Another reason for keeping the headwater down to the normal crest level is the danger of flooding land above, in connection with which it has not been considered necessary to acquire flowage rights. There is nothing more productive of interminable and costly legal difficulties than interference or trespass in connection with the riparian rights of property owners along a developed watercourse, but if the project has been properly laid out and the water is kept at a point, there is little likelihood of trouble from this latter source.

In many forms the timber dam was at one time commonly used for low-head developments,

Pointers of value to the operator on the different types of dam employed, the various spillways and gates, fishway and log chutes, and canals or pipe lines carrying the head water to the most desirable location.

*Instruction department, Consumers Power Company.

owing to the proximity and cheapness of the material, and the fact that such a dam could be built quickly. But however well designed and built, the timber dam cannot be considered as permanent as either the earth embankment or the masonry structure. Timber under water has a fairly long life, but under average conditions of stream flow and operation some parts of the timber work will be alternately wet and dry, which brings about a condition of decay that greatly shortens its life, so much so that the rules of the Conservation Commission of the State of New York provide that the timber of the dam shall be removed at the end of five years, unless express permission is granted to cover a longer period. This lack of permanence and the present increasing scarcity and cost of suitable timber in most parts of the country would seem to make it unlikely that any important future dam of this type will be built, and those that remain will require increasing attention and expense to keep them in good condition.

Most of the larger dams are built of stone or concrete, or of a combination of the two. The style of construction depends on the height of the dam and the amount of water imponded. Cyclopean masonry, in which masses of stone as large and heavy as can be handled are embedded in concrete, the structure being faced with ashlar, molded concrete and rubble masonry laid in cement mortar are the usual methods of construction, and if the dam is well bedded in good, sound rock underneath and at the ends, a massive, permanent structure is obtained that should stand for many generations and require little expenditure for maintenance. On any dam the type of spillway depends on local conditions. If the freeboard is high, so that a considerable rise in the pond may be permitted without danger of flooding property upstream, an open spill or rollway is provided. The crest may be raised by flashboards during the dry season and a considerable amount of water ponded and a better head maintained, which is important in a low-head development.

Flashboards consist of one or two planks set up on edge and supported by wood stakes or solid iron or pipe pins driven in holes made for the purpose in the crest of the dam or, in case of a wood dam, brackets nailed to the crest. The supports should be so proportioned that they will bend or break before the water gets high enough to do any damage upstream. It is best, of course, to remove the boards and save them in case of an expected freshet. Ordinarily, but little water should be permitted to spill over this type of flashboard.

Sometimes a needle section (Fig. 6) is placed in the spillway of a movable-crest dam. This consists of a horizontal sill and top girder against which upright "needles" of about 6 x 6-in. timber are set, slightly inclined downstream. Against these needles planks are laid to hold the water. In case of sudden need to spill, if the gates are frozen—a condition that never should occur—the top planks or all of them may be removed with a pike-pole, or in case of emergency the needles may be chopped clear and the whole section permitted to go downstream. This, of course, would be costly, but might prevent serious damage.

The tainter gate is like a section cut out of a large wheel, the gate being a sector of the rim with its convex face upstream, and braced against the hub and

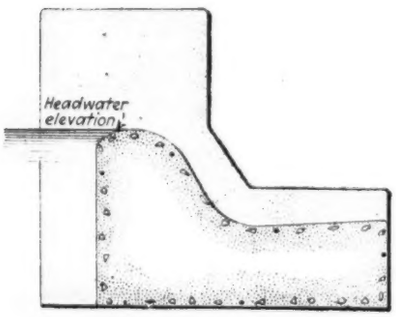


FIG. 1. OVERFLOW SPILLWAY

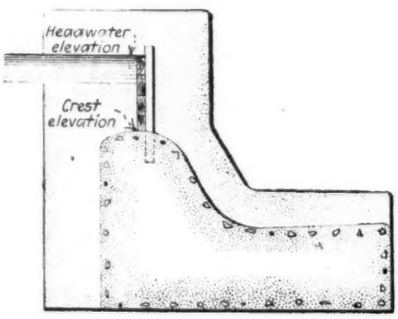


FIG. 2. ARRANGEMENT OF FLASHBOARDS

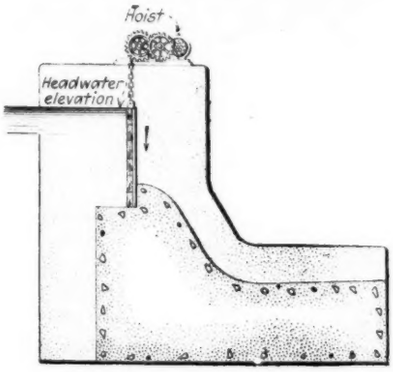


FIG. 3. VERTICAL-LIFT GATE, SPILL UNDERNEATH

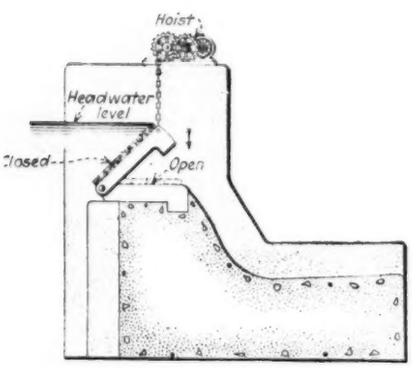


FIG. 4. TILTING GATE OR BEAR-TRAP, OVERFLOW SPILL

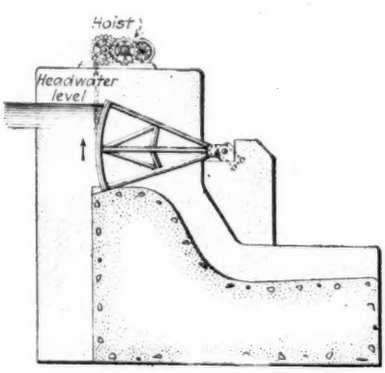


FIG. 5. TAINTER GATE, SPILLS UNDERNEATH

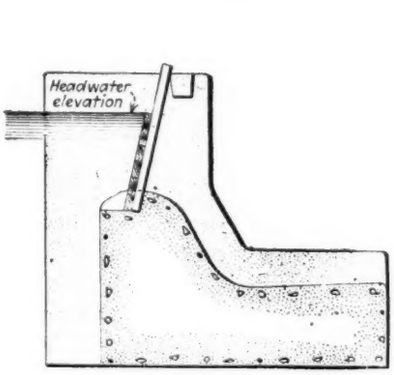


FIG. 6. NEEDLE DAM, OVERFLOW SPILLWAY

shaft by the spokes. The spill is underneath, and the gate is raised and lowered by a hand- or motor-operated hoist, which is usually set on a track above the spillway, one hoist serving for several gates. The lift is by means of heavy chains permanently attached to the bottom of each gate and wound and connected to the hoist when the gate is to be operated. At other times the chain is secured by a special link that grips it across an opening directly over the gate, which may thus be left in any position and the hoist moved to the next gate.

Sliding gates (Fig. 3) are raised and lowered in slots in the masonry, which are usually reinforced with channel irons. These are handled similarly to the tainter gates, though the portable hoist is less frequently used. A special arrangement of winding drums connected to a shaft with a clutch, the shaft being driven by a motor through suitable gearing. is more common. Many of the smaller gates are screw-operated, the nut being turned by levers or through gearing by hand or motor. Some of the older types are handled by lever and ratchet or by rack and pinion. These are usually operated by hand.

The "Bear Trap" Gate Developed

The "bear trap" is a development of the flashboard. The first step from the pin-supported boards which have been mentioned was to build the flashboards in sections, hinged to the dam at the bottom, so that if the pins bent or broke, the boards would simply fall over, and as soon as the water was down they could be set up again.

A number of designs followed, some of them ingenious, which permitted lowering the "trap" and in some cases raising it, without the necessity of wading out on the spillway, but these are no longer in general use. The bear-trap gate in use today is generally a massive affair of plate-girder construction, hinged to the dam at the bottom, raised and lowered by means of a hoist, and generally counterbalanced, so no great amount of power is required to operate it. If not too long, these gates work very well.

A later development of this style of gate is the automatic bear-trap. In this the gate is closely counterbalanced, so that when the water reaches the maximum height, the gate tilts from the pressure, and as soon as the water is down, rights itself again.

Space does not permit a description of every style of gate in use, but the examples cited will cover in general the practice in the construction of movable crests for the control of spill, where the head and freeboard are low, so that it is necessary to have the permanent crest considerably below the normal level for safety in floods.

Fishways and Log Chutes

Most water-power men have their own opinion as to the practical value of the fishway for the purpose intended, but in most localities the law demands them, and of course the law must be obeyed. If the fishway is of timber, and especially if it passes through an earth embankment, it is necessary to make periodical inspections to prevent leakage that might cause serious damage. Where lumbering operations on a given watershed include the use of the stream for driving logs, a small slide gate is generally provided for the passage of the logs through the dam, especially if the dam is of the movable-crest type. A trough of wood or concrete is provided, in which the logs are carried clear of the dam. A boom is, of course, necessary to prevent the logs being drawn into the racks, and the drive should be handled by men who understand this line of work.

If the natural head for a power development is obtained from a series of rapids, a canal is generally necessary to carry the headwater to a point where the shortest and most nearly vertical drop may be obtained to the lower level. In some cases a high dam across a narrow valley will concentrate the fall, but more often this cannot be done.

Canals and Their Construction

Usually, the canal is an excavated ditch of trapezoidal section, but often is located on a side hill, where one side is an earth embankment. It does not seem to be the general practice to build a core-wall in such an embankment unless the slope is so steep that the embankment cannot otherwise be made stable and impervious. The banks of the canal require some attention to see that the water does not overflow, and to watch for leaks due to muskrats, gophers or other rodents burrowing through the bank. Erosion of embankments by rain must be looked after, and in this connection the formation of a strong and deep-rooted sod is desirable.

Willows may be planted along the foot of the bank to good advantage. All that is necessary is to cut stakes five or six feet long and drive them into the ground. The majority of these stakes will take root and grow, and in a few years there will be a dense growth, the interlaced roots of which will tend to bind the soil together, and the trunks will form buttresses along the banks. Willows should not be planted too close to masonry walls, as the roots might find their way into cracks in the wall and in time split it open. Neither should the trees be permitted to grow so high that there is danger of their being uprooted and blown down by the wind, as this might be fatal to the embankment.

If leaks occur in these banks from burrowing rodents, probably the best material to use in stopping them is cinders. A small cofferdam around the leak will permit digging the hole out, so that it may be entirely filled. Some gravel or clay will make the cinder filling more stable, if the hole is of any size. Fortunately, these ratholes are not usually much below the surface of the water, so there is little pressure on them. It is good practice to keep a rifle at the plant for shooting these little marauders on sight, unless they are protected by the game laws, and they should be trapped in the trapping season. They are a nuisance, and their work is dangerous not only to the canal, but in some cases to property that might be flooded should the embankment give way.

The Construction of Pipe Lines

Pipe lines are used in locations where the topography is such that a canal cannot be built the whole distance to the plant, and where a considerable head can be obtained by carrying the water to a point at a distance from the dam, but which cannot be reached by canal. One point on the pipe line that should never be lost sight of, is that the longer it is the more difficulty there is in handling the mass of moving water in it. This will be covered more in detail when considering some of the problems of load and speed regulation of a water turbine. A large pipe line sev-

eral miles long will contain a tremendous weight of water, and if this mass is stopped without provision for taking up its kinetic energy, something is likely to let go. Where conditions permit, this danger is minimized by the installation of a surge tank as close to the plant as the requisite elevation of the top of the tank can be had, and where this cannot be done, some sort of positive relief must be provided, so that there never will be a sudden stoppage of the water.

Pipe lines are generally of riveted steel plate or of wood-stave construction. The steel-plate tube is used where the pressure is high and where it is more economical than the wood pipe in first cost and transportation. The wood-stave pipe is in general use in the West, and for a moderate head, up to 200 or 300 ft., gives good satisfaction. The staves are held together by heavy, round steel hoops, which are adjustable, the ends being threaded, passed through a special casting and drawn up with a nut on either end before the pipe is filled. On filling, the wood swells and tightens the joints so there is little or no leakage. While a wood pipe is not as permanent and stable as the open canal, as a general thing, if well built of proper material and kept filled with water and handled intelligently, it may be made to give efficient service for years.

In filling a pipe line care must be taken to fill it slowly so that no great body of water will go rushing toward the delivery end. Every cubic foot of water weighs 62.4 lb., and a simple calculation of the cubical contents of the pipe will demonstrate that the weight of the water, especially when it is in motion, is formidable. In emptying a pipe line care must be taken not to let the water out more rapidly than the air can enter.

Monarch Soot Blower for Vertical Water-tube Boilers

It is necessary to remove soot from vertical water-tube boilers as from boilers of other designs, but soot blowers for such boilers are not so well known as those for other types. The device illustrated herewith is designed for use with vertical boilers. It is simply to install with boilers having brick setting, and when a steel casing is used the unit is bolted to it.

The unit consists of a number of blowing nozzles, each having two openings. The directions taken by the steam from the two openings are such that soot is blown from all portions of the tubes as the nozzles are moved from one extreme position to the other. The header to which the nozzles are connected is fitted with a gear which meshes with a worm on the shaft, the latter being turned with a crank during the period of blowing.

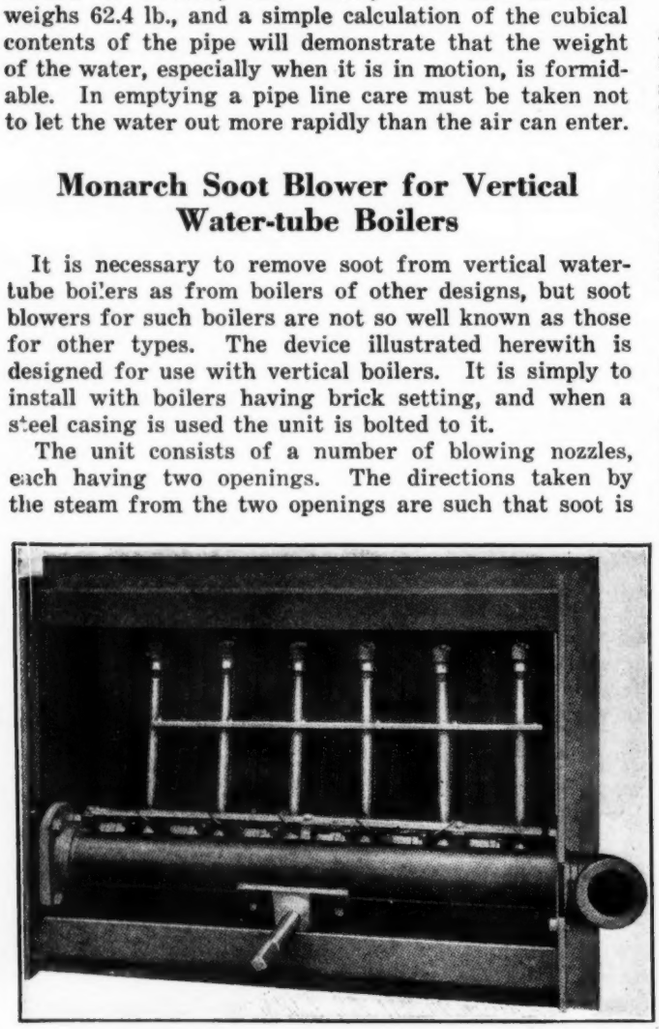


FIG. 1. NOZZLES SWUNG BACK AND SHUTTERS CLOSED

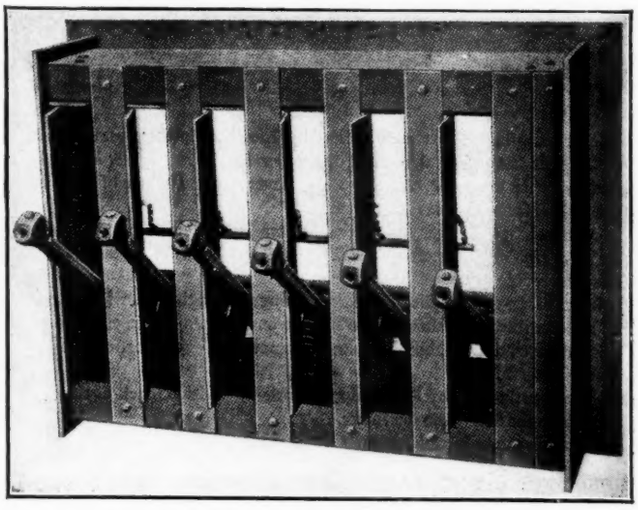


FIG. 2. NOZZLES PROJECTING THROUGH OPEN SHUTTERS

Fig. 1 shows the nozzles swung back out of the heat and the shutters closed, thus protecting the entire mechanism from the heat of the furnace gases. Fig. 2 shows the side of the unit that faces the boiler tubes. The nozzles are shown projecting through the open shutters. This unit is designed for the third pass of a vertical boiler; on the first and second passes brick is substituted for the flat spacing between the shutters. This blower can be installed on any vertical water-tube boiler. It is manufactured by the Monarch Soot Remover Co., Inc., 261 Franklin St., Boston, Mass.

During the winter of 1917-18 a serious situation arose in the steel industry, because great congestion prevented the mid-continent blast furnaces from receiving a sufficient supply of the metallurgical coke made from Eastern coals. The mid-continent coals near at hand had not been successfully used in the making of coke for blast furnaces. At the request of the American Coal and Byproducts Coal Co., the owners and operators of the Roberts process, an extensive test was run by the Bureau of Standards with the co-operation of the Bureau of Mines and the Geological Survey. A continuous test was made for about two weeks, operating twenty-four hours a day, and during this test about 4,800 tons of Illinois coal was used. The coke obtained was used in a near-by blast furnace, but on account of limited supply it was necessary to use a certain amount of coke from Eastern coal, which rendered the test less conclusive. However, very good pig iron was obtained from the mixture, and it was the opinion of the blast-furnace superintendent that the furnace would operate perfectly with 100 per cent of the Midwest coal. It is believed that this process holds promise of permitting the satisfactory use of mid-continent coals for the manufacture of metallurgical coke. Byproducts of good quality were obtained in the following quantity per ton of dry coal: Toluol, 0.43 gal.; benzol, 0.5 gal.; ammonium sulphate, 26 lb.; tar, 10.7 gal.; gas, 10,000 cu.ft. (approximate).

The Electrical Method of Detecting Surface Condenser Leakage

By W. E. CALDWELL

THE electrical method of detecting leakage is based on the electrical conductivity of the water to be tested. The conductivity of pure water is exceedingly low, while the addition of soluble salts increases it nearly in proportion to the quantity added. While all salts, or soluble impurities, do not increase the conductivity to the same degree for a given concentration, this has little importance, since the relative amounts of the different salts in most raw waters do not vary greatly, and the slight variations may be overlooked. The conductivity of water containing dissolved salts increases with increase in temperature, and the temperature coefficients for the different salts vary slightly. However, the coefficients approach a common value for very dilute solutions, so it is possible to compensate relatively closely for temperature variations or correct the indications to a standard temperature.

The electrical method of detecting condenser leakage possesses the advantage over the chemical or silver-nitrate method in that it may be employed where the raw water is free from chlorides. Furthermore, it may be rendered more sensitive than the chemical method, with the added advantage of recording the amount of condenser leakage on a chart. This method makes use of an insulated plug, illustrated in Fig. 2, that is screwed into the condensate line, a recording ammeter (0.5 ampere full scale) and a 110-volt alternating-current source of supply. Another method is employed, in which a relay or ordinary telephone drop is substituted for the ammeter and wound to operate at a predetermined amount of leakage, giving an indication when this amount is exceeded, by lighting a light or ringing a bell. The apparatus for the latter method is shown in Fig. 1.

THE leakage of cooling water charged with impurities through the innumerable joints of a surface condenser is an ever-present trouble in steam-plant operation. Condensed steam should provide an ideal feed water, practically free from dissolved salts; yet the leakage of relatively small quantities of raw water into the condenser may so increase its content in scale-forming or corrosive substances, as to render it unfit for use in the boilers. It is therefore most important to detect and, if possible, to measure the leakage in every condenser in a plant. This article describes an ingenious method of obtaining a continuous graphic record of the leakage, by measuring and recording the electrical conductivity of the condensate, for the conductivity of the condensate may be assumed without serious error to be directly proportional to the amount of raw water that has been mixed with it.

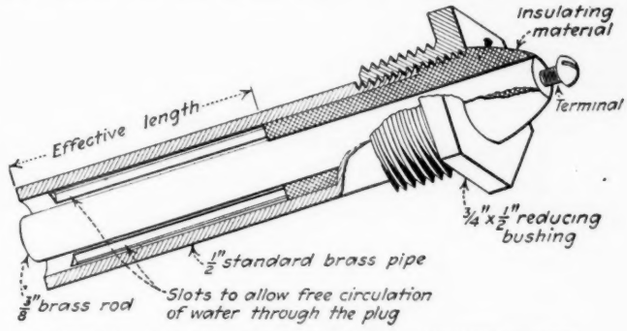


FIG. 2. PLUG FOR MEASURING CONDUCTIVITY OF CONDENSATE

The plug is screwed into the condensate line, and current flows through the terminal of the plug into the inner electrode or brass rod, from this through the volume of condensate inclosed between the brass rod and the outer electrode or brass tube, and thence to the ground through the screw threads and the condensate piping.

The plug is made from a piece of standard half-inch brass pipe (bore $\frac{5}{8}$ in.) usually about $3\frac{1}{2}$ in. in length with an inverted $\frac{1}{2}$ by $\frac{3}{4}$-in. bushing screwed on one end. A $\frac{3}{8}$-in. brass rod about $4\frac{1}{4}$ in. in length is in the center of and insulated from the brass pipe with hard rubber or other insulating material to within two inches of the bottom. The uninsulated portion at the bottom is referred to as effective length. The lower end of the pipe contains four longitudinal slots $\frac{3}{16}$-in. wide, equally spaced around the circumference and extending from the bottom of the insulation to within $\frac{1}{4}$ in. of the bottom of the pipe. The purpose of the slots is to permit the free circulation of water between the pipe and rod. The upper end of the rod terminates in a binding post. This type of plug is used with the ordinary 110-volt 60-cycle alternating-current lighting circuit, one side of which is grounded. Such a plug cannot be used with direct current, since polarization, due to the small gap, would render it useless. By increasing the effective length of the plug, the apparatus may be made to respond to the minimum amount of leakage that it is desired to indicate.

The electrical connections are simple, as shown in Fig. 3. Upon screwing the plug into the condensate pipe, or metal tank, the outside is grounded through the threads, so it is necessary to run but one wire, from the plug through the ammeter and fuse thence to the ungrounded side of the line. A pilot light is connected between the fuse and ammeter to ground to indicate that the circuit is alive and that the fuse is intact. With pure condensate, the current that flows across the

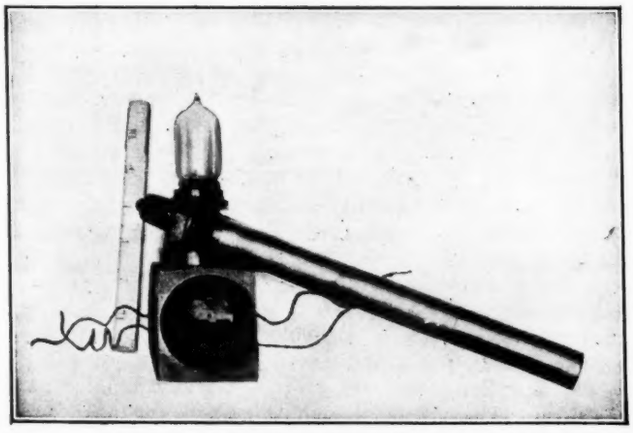


FIG. 1. APPARATUS FOR DETECTING LEAKAGE WITH A RELAY AND ALARM-LAMP

The relay is set to light the lamp when the leakage exceeds a certain value.

gap in the plug and through the circuit is too small to produce a deflection, while any leakage sufficient to bring the total solids in the condensate up to one grain per gallon gives an appreciable indication with a plug of two inches effective length. With a plug having six inches of effective length, an indication is obtained on water having as little as 0.1 grain of solids per U. S. gallon. Six inches is about the maximum effective length that may be employed, since beyond this length pure condensate itself begins to indicate at high temperatures, and operating men soon lose confidence in the indications. Ordinarily, a plug of about two inches effective length should be used on individual units, whereas in a common condensate line from a number of units it is advisable to have this length four or five inches.

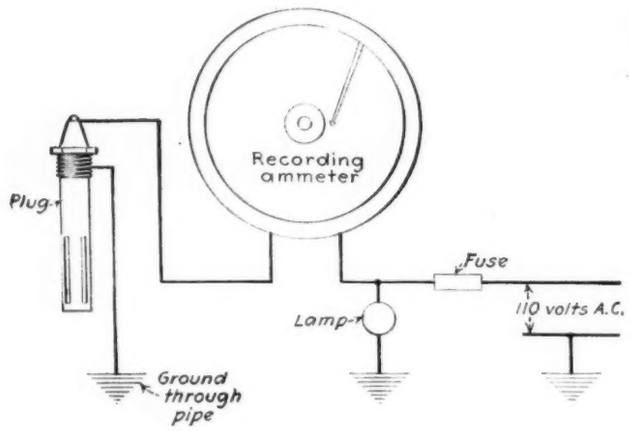


FIG. 3. ELECTRICAL CONNECTIONS FOR MEASURING LEAKAGE

Note that the connection shown from the screw threads to the ground is fictitious and merely indicates that the outer electrode of the plug is grounded through the screw threads and the condensate piping.

The electrical method may be employed in testing the concentration of boiler water under certain conditions, but unaccompanied by chemical tests the results are likely to be misleading. The indications do not distinguish between chemical treatment in the water and accumulated impurities, both of which have the same effect on the conductivity of the water, so it may be seen that a high indicated concentration does not necessarily mean that conditions are bad. Thus sodium carbonate gives about the same indication as an equal amount of magnesium chloride or an equal amount of almost any other corrosive salt. It must be borne in mind that the indications of the instrument give no clue as to the nature of the salts present, but simply indicate that the aggregate mixture of the salts in the water amounts to so much.

Fig. 4 gives the results of a laboratory calibration of a plug, having two inches of effective length, corrected to 110 volts. While sodium chloride was used in the calibration, the results apply to most of the other salts or combinations of them. These curves show the effect of temperature upon the conductivity, which is also common with most salts or combinations. Where it is desired to refer the reading at one temperature to some other or standard temperature, it may be done by adding 5 to the temperature observed and to the standard desired and multiplying the ratio of these figures by the observed current. Thus suppose a reading of 0.46 ampere is obtained on condensate at 142 deg. F. and it is desired to refer it to 100 deg. F. By multiplying 0.46 by $\frac{100 + 5}{142 + 5}$ we get 0.328 ampere as the current at 100 deg. F., hence the water would contain one grain of solids per U. S. gallon, as may be seen from the curves.

Fig. 5 shows the sensitiveness of plugs of varying effective length with water at 85 deg. F. and is useful in selecting the size of a plug for a given service. For example, if the maximum leakage it is desired to measure will contaminate the condensate to the extent of 1.5 grains of solids per U. S. gallon, an effective plug length of 2.5 in. will give a full-scale deflection on an 0.5-ampere ammeter at 85 deg. F.

For use in detecting condenser leakage, it is more convenient to plot the curves in terms of per cent leakage, as this indicates the magnitude of the leaks directly without the necessity of considering the quality of the circulating water. With the help of a graduated cylinder, a solution of pure water containing 1 per cent of the raw circulating water may be made. By determining the deflection of the apparatus on this 1 per cent solution at a given temperature, it is possible to compute approximately the quantity of total solids in the raw water, by referring to the curves in Figs. 4 and 5. From this it is also possible to plot curves showing the amount of leakage corresponding to the indications of the ammeter at any given temperature. In determining the indication of the apparatus on the 1 per cent solution, it is important to agitate the water thoroughly while noting the temperature and current, since there is a tendency for the passage of the current across the gap to heat the water in the plug above that of the outside water where the thermometer is located.

Fig. 6 shows typical leakage curves plotted from a laboratory calibration using a plug having 1.5 in. effective length and a 110-volt alternating-current. The raw water contained about 950 grains of solids per U. S. gallon, over 600 grains of which existed as chlorides. The water also contained 42 grains of calcium sulphate and 15 grains of calcium carbonate, which were the principal scale-forming ingredients present. The curve marked "Croton Water" shows the conductivity of New York City water as tested several years

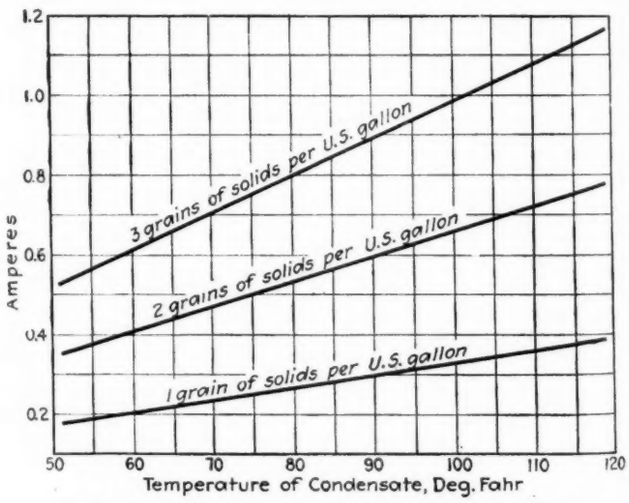


FIG. 4. CALIBRATION CURVES OF 2-IN. PLUG

Giving the current-carrying capacity of water on 110 volts at different temperatures, with different proportions of chemical solids in solution.

ago, at which time it contained 0.3 grain of calcium sulphate and 1.2 grains of calcium carbonate per gallon, together with other solids bringing the total to 3.3 grains per U. S. gallon. The position of the Croton-water curve relative to the others conforms approximately to the quantity of salts present in the solution, since the Croton water contained 3.3 grains of dissolved impurities per gallon, as would a 0.35 per cent solution of the raw water. However, the relation of the curves indicates little as to the scale-forming or corrosive impurities present. Considering the principal incrusting impurities in the two waters, it may be seen that a 2.6 per cent solution of the raw water is no worse than Croton water from this viewpoint alone, except on account of the greater proportion of sulphates present in the former. The Croton water, on the other hand, was entirely free from corrosive salts that were present in the raw water, and for this reason was considered

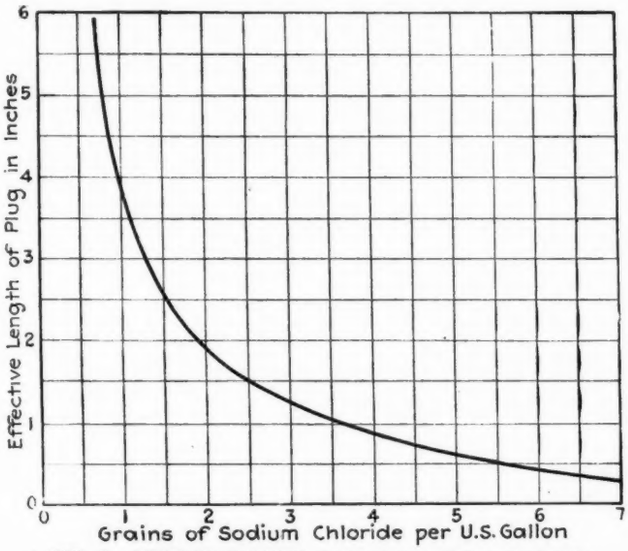


FIG. 5. SENSITIVENESS OF PLUGS OF DIFFERENT LENGTHS

This curve is useful in determining the lengths of plugs to be used with waters of different strengths. It is plotted between the strength of the solution and the effective plug-length necessary to give full-scale deflection on an 0.5-ampere ammeter.

superior for feed water to condensate contaminated with as little as 0.5 per cent leakage.

In installations where all the condensate from a number of units discharges into a common condensate line, it is advantageous to have a plug located in this line and connected to a recording ammeter. A close check on the total leakage may thus be obtained graphically. In order to detect which particular unit is leaking, a number of methods may be employed. The one giving the quickest results requires a plug in the condensate line from each unit wired to contacts on a rotary switch at the ammeter, so that each unit may be connected in succession to the ammeter until the faulty one is found.

In the absence of a common condensate line the graphic record of condenser leakage for the entire system may be obtained by another method, although less accurate than the first. From each plug in the individual condensate lines a wire is run to the recording ammeter, with a switch in each wire so that they may all be cut in parallel. The ammeter then records the current taken by the plugs collectively. With any indication of excessive leakage on the system each plug may be cut out in succession until the faulty unit is located. One objection to this method is the fact that the condensate temperatures of the individual units may vary widely, hence the average leakage represented by the ammeter will be subject to slight error on this account. In most plants, however, the deviation in

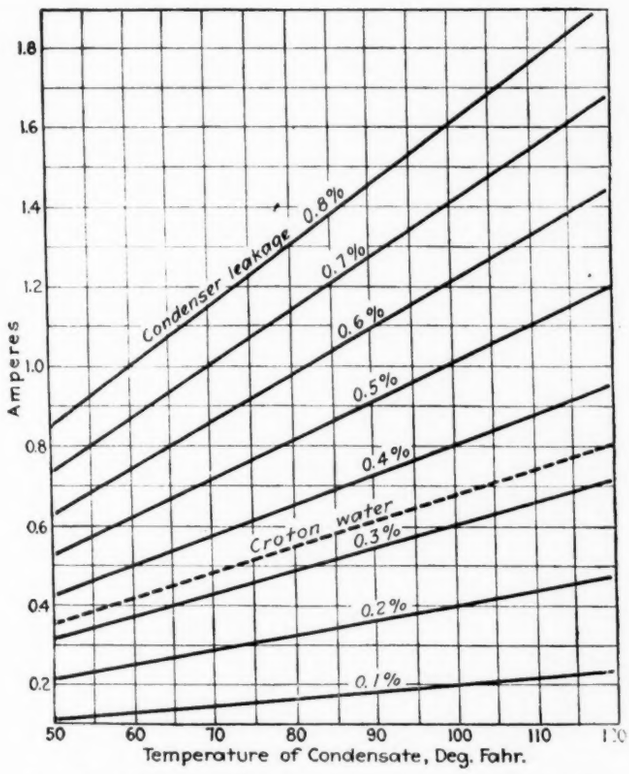


FIG. 6. CURVES FOR CALIBRATION OF 1½-INCH PLUG WITH A GIVEN RAW WATER

These curves are similar to those in Fig. 4 for a 2-in. plug, with the exception that the solid content of the water has been computed into the actual leakage of a given quality of raw water that will give that composition. For instance, the line for 2 grains of solids per U. S. gallon in Fig. 4 would be labelled in Fig. 6 by the actual percentage of leakage that would introduce 2 grains of solids per U. S. gallon into the condensate.

temperature between individual units is hardly sufficient to condemn this method.

One outstanding feature of the electrical method is its ability to detect leakage into condensers, which by the ordinary methods of testing would have been pronounced tight. The chart reproduced in Fig. 7 was

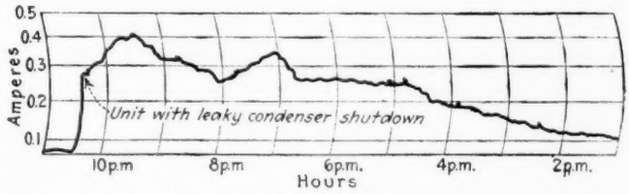


FIG. 7. CHART OF THE TOTAL LEAKAGE IN ALL THE CONDENSERS OF A LARGE CENTRAL STATION

Showing the gradual development of a leak. At 1 p.m. the leakage indicated only 0.1 ampere. At 9:30 p.m. it had increased to 0.41. At 10:28 p.m. the offending unit was shut down and the combined leakage of the remaining units indicated only about 0.03 ampere.

taken from the leakage recorder on the common condensate line in a large plant and illustrates the gradual development of a leak. The effective length of plug used was six inches, and the temperature 86 deg. F., so it may be observed that at the maximum reading (0.41 ampere) the leakage was approximately 0.06 per cent on the entire system. This corresponds to about 0.6 grain per gallon on the total condensate.

Non-Condensing Turbine Operation on Heating Load*

Decentralized Plants or Units To Recover Electrical Energy from Heating Steam—It Is Proposed to Limit the Attendance for These Machines to Periodic Inspection

By R. D. DeWolf

In 1917 the Rochester Gas and Electric Corporation installed a 750-kw., 60-cycle turbine-driven non-condensing unit in one of its substations, for supplying low-pressure heating steam to one of its largest steam-heating customers. Due to war conditions, there was some delay in getting this machine installed, and it was not until the fall of 1918 that much operating was done. Since then, the operation has not been as continuous as might be desired, but it has met with sufficient success to show with fair accuracy what might be expected under normal conditions. It is the purpose of this paper to outline these reasonably assured expectations rather than to give a full and complete history of all the actual operation.

Reaction Turbine Installed

The machine installed is a reaction turbine driving a 60-cycle alternator through a reduction gear. The turbine is equipped with two sets of nozzles, one set carrying the machine up to a capacity of about 350 kw. and both sets being used for loads higher than this. Fig. 1 gives the guaranteed water rates for the turbine with a steam pressure of 150 lb. and for the different back pressures. Another curve shows the increase in water rate with back pressure. It will be noticed that this increase in steam rate increases as the load in the machine decreases.

This turbine is supplied with steam through a high-pressure 8-in. line about 2,000 ft. long. The actual pressure at the turbine varies considerably, according to the load on the machine, but rarely drops below 150 lb. at the throttle for any considerable length of time. Much of the time, however, it is higher than 150 lb., running up to 190 or 195 lb. on light loads. The figures in the table have been taken from operation during the heating season of 1919 and 1920. For the sake of comparison the pounds of steam per kilowatt-hour taken from the curve for 5 lb. back pressure have been included. There is considerable variation in the results, due probably to varying pressure at the turbine inlet, varying back pressure and varying load conditions, over which the operator had no control. The days on which these figures are based were selected according to the average load on the turbine during the period of actual operation, which varied from five to twenty hours. The days on which a certain average load was attained were not all in the same month, so that weather conditions were different, though the average load was the same.

Steam Consumption per Kilowatt-Hour for Season of 1919-20

Average Load Kw.	Actual Steam Consumption Lb. per Kw.-hr.	Consumption for 5 Lb. B.P. Lb. per Kw.-hr.
263	57.7	47.3
355	48.0	47.2
457	47.7	46.8
538	49.0	46.4
686	44.4	44.4

As it was felt that there should be a relation between the outside temperature and the kilowatt-hours generated, an analysis was made of the operating results on this basis, and the curves shown in Fig. 2 were plotted. The curve indicated by the crosses gives the average kilowatt-hours generated per day for a given daily average outside temperature for the days operated during the heating season of 1919-20. In making up this curve, 5-deg. steps in outside temperature were taken and the operating results on days falling within each one of these steps were averaged and plotted. This curve shows a falling off at the lower temperatures.

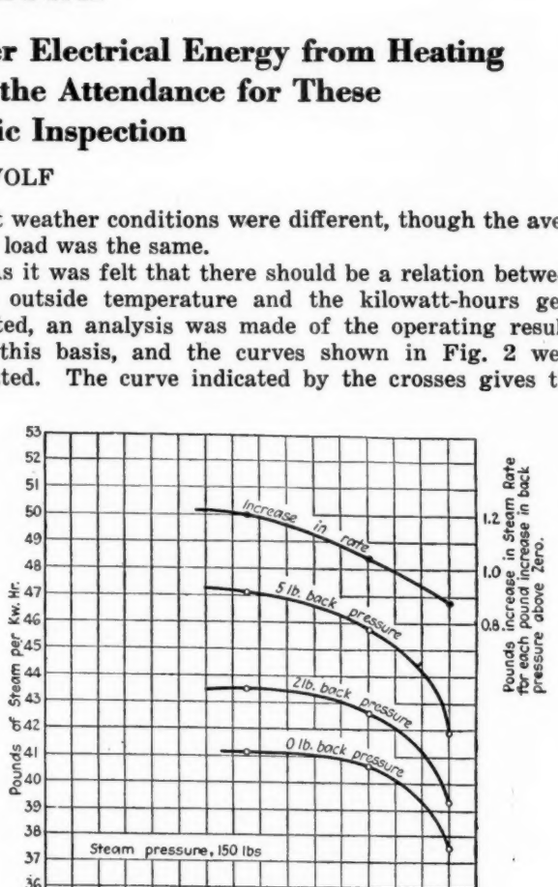

Increase in rate
5 lb. back pressure
2 lb. back pressure
0 lb. back pressure
Steam pressure, 150 lbs
Pounds of Steam per Kw. Hr.
Kilowatts
Pounds increase in Steam Rate for each pound increase in back pressure above Zero.

FIG. 1. WATER-RATE CURVES OF NON-CONDENSING TURBINE FOR DIFFERENT BACK PRESSURES

Water-Rate Curve for 1920-21

A similar curve, indicated by the dot with the square around it, was drawn for the year 1920-21. This curve is considerably higher than the curve for 1919-20, the difference for any given outside temperature amounting to about 3,000 kw.-hr. per day, except in that portion where the 1919-20 curve for some unknown reason shows a tendency to fall off.

This difference between the two is due to a larger load during 1920-21, longer hours' operation per day and probably to the installation of an automatic device for varying the load on the turbine so as to maintain a constant back pressure on the machine.

The device mentioned was an automatic valve installed in the main steam line to the turbine, which automatically maintains a constant back pressure by

*Paper presented before the National District Heating Association, Cedar Point, June 23, 1921.

closing or opening as the pressure in the turbine exhaust rises or falls. During the previous season the load on the turbine had to be adjusted by hand control on the turbine governor. After the installation of the automatic valve, the turbine governor was adjusted so that it would have no effect on the amount of steam being supplied to the turbine, unless the turbine exceeded its normal speed by 5 to 10 per cent. This resulted in maintaining not only a more uniform exhaust pressure, but also a higher average load on the turbine and a larger kilowatt-hour output than could be obtained by hand regulation.

Checking Results of First Two Curves

As a check on the results plotted in the first two curves of Fig. 2, two other curves have been plotted showing the average kilowatt-hour generation per day for a given monthly outside temperature, the operating results for a complete month being averaged and indicated by the dot in the circle for 1919-20 and a dot in a triangle for 1920-21. These points in general fall close to the curves determined by averaging all days of a given temperature, irrespective of the month in which they occur. While they are of little value in analyzing the probable operating results for any other plant, they give a means of determining what the present installation should do.

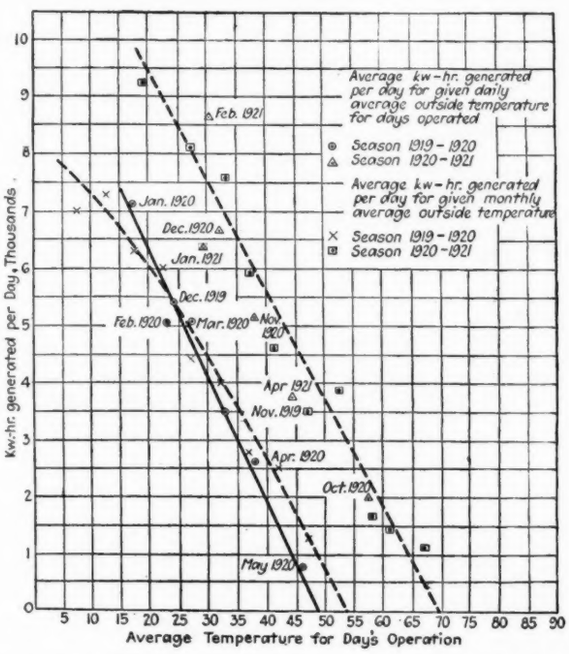


FIG 2. KILOWATT-HOURS GENERATED PER DAY BY NON-CONDENSING TURBINE FOR DIFFERENT OUTSIDE TEMPERATURES

In general the results are promising and show a good return on the investment involved. They also indicate that in any case except where the exhaust-steam demand on the turbine is phenomenally constant, satisfactory operation cannot be attained without the use of automatic control on the turbine, especially when the outside temperature is above 40 deg. Remembering that a large proportion of the days during the heating season show an average temperature of 40 deg. or above, the importance of automatic regulation in year-around operation is emphasized.

In the particular case under consideration the turbine was installed in an existing substation containing rotaries and motor-generators, so that no additional operators were put on. While a part of the time of the operators is charged against turbine operation, the labor expense is small, and in any case where this labor expense can be kept down to a minimum, the installation of machines of this type will prove to be profitable.

Operation Without Attendance

However, it is not always possible to install these machines in existing substations, locating the machine at such a point that the investment required in the low-pressure mains for distributing low-pressure steam is of primary importance. This often means that the turbine should be located in basements or small buildings away from any other apparatus belonging to the steam company, and if it were necessary to put on operators simply to take care of the operation of an individual unit, the labor costs would be prohibitive. To overcome this difficulty, the company is considering the installation of turbines that will be kept in regular operation without attendance, but merely inspected from time to time.

Usually, a turbine either operates practically 100 per cent or else becomes inoperative, and the ordinary power-plant operator is unable to overcome the difficulties that render the machine inoperative. The operating problem is quite different from that of a reciprocating engine, where a little adjustment may remedy a temporary defect and the operator may thereby get the machine back into operation in a relatively short time. The turbine is a self-contained unit, supplying its own oil automatically and is so designed that there are practically no adjustments an operator can make to get the machine back into operation in a short time in case anything goes wrong. Furthermore, if anything happens, it generally happens so quickly that the operator has little opportunity to limit the extent of the damage.

Reducing Valve and Safety Devices

In view of these characteristics of the turbine, it is perfectly feasible to operate a non-condensing machine on a heating system at such a point as may be most advantageous from the viewpoint of economic distribution of the steam without any regular attendant. A reducing valve would be installed so that, in case the turbine shuts down, steam would be supplied to the low-pressure system. In addition, certain safety devices should be installed on the turbine so that, in case the machine lost a blade and began to vibrate, or if the oil reached too high a temperature or the supply of oil to the bearings stopped, the machine would be automatically shut down. Special precaution should be taken to prevent a runaway. All of these things are capable of solution by the application of the proper devices.

With several such installations, one man could be assigned to make a regular inspection of each turbine every two or three hours and start and stop the machines at such times as it was necessary to do so. By thus eliminating 90 per cent of the labor cost in connection with the operation of these non-condensing units, the economic advantages of supplying low-pressure steam for heating purposes by this means are greatly increased.

Operation of Diesel Air Compressors

By LOUIS R. FORD

A VERY essential part of any air-injection Diesel engine, the class into which most Diesel engines fall, is the air compressor, which compresses the air required for injecting the fuel into the cylinders. Even the engines that do not use air for injecting the fuel require a compressor for supplying air for starting, but in this latter case the compressor capacity required is not so great and the pressures carried are not so high. In the past a very large proportion of the operative troubles with Diesel-engine units has been air-compressor trouble. For this reason air-compressor design and operation have of late years received an increasing amount of study.

It is an established practice in Diesel-engine building to attach the compressor directly to the engine, so that it operates only when the engine is running and its speed varies with the engine speed. In most installations the compressor is operated by means of a crank and connecting rod on an extension of the mainshaft, the air-compressor crank being simply an additional crank on the mainshaft, but in some engines the compressor is mounted on the engine framing and driven by means of walking-beam levers attached to one of the main crossheads. A third arrangement found on some small engines drives the compressor by means of an eccentric on the main crankshaft. In some cases the compressor is not attached to the main engine, but forms an independent unit, driven by an electric motor or a small Diesel engine.

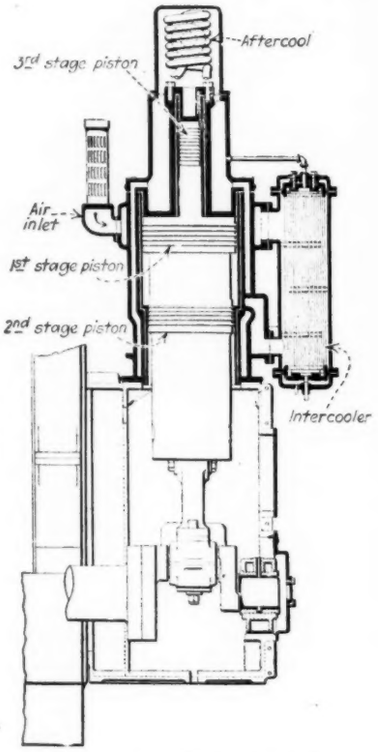


FIG. 1. THREE-STAGE AIR COMPRESSOR

Because of the high pressure to which the air must be compressed to provide adequate pressure for spraying the fuel, and the great temperature increase involved in this compression, multi-stage compressors are always used, the compression occurring in two, three or four steps, or stages, the most universally used arrangement being the three-stage. Fig. 1 shows a three-stage arrangement, while Fig. 2 outlines a two-stage compressor used on small engines. This staging permits cooling the air after each step in the compression and thus keeps the maximum temperature of the air within safety limits, but it necessarily involves the use of more valves and other mechanical complications that may be the cause of troubles in operation. In all cases no matter what the arrangements may be as to staging, location and method of drive, the operating procedure and adjustments are of the same general nature.

Leaky Compressor Valves

The majority of operating troubles arise from the valves and are due to one of the following causes: Dirty, warped or broken valves; leaky gaskets under the valve cages; carbonized oil on the valve or valve seat. Because of this fact a great deal of ingenious thought has been applied to the improvement of valve design, resulting in a large number of different kinds of valves.

The operator's surest guide to the condition of his compressors is the gage board. The pressure gages for the different stages should be conveniently located at the operating station where they can be easily seen. Any change in pressure ratios as shown by the gages is a sure indication of some changes in conditions within the compressor or in the air system. The immediate result of leaky valves, whatever the cause of leakage, is reduction of capacity, followed by abnormal heating of some part of the compressor. If the capacity reduction proceeds far enough, the engine will become smoky, due to low air pressure and imperfect combustion, and finally stop for want of sufficient air to spray the fuel into the cylinders.

Rise of pressure in the first stage, as shown by the gage, indicates a leak in the second-stage suction valves; similarly, a pressure rise in the second stage indicates a leak in the third-stage suction valves. In each case the air from the higher stage is blowing back through the valves into the lower-stage receiver. In the case of a pressure rise in the third stage, however, a restriction in the air-discharge system beyond the compressor must be looked for. This may be caused by clogged strainers, partly closed stop valves, stuck check valve, or clogged spray valves. Leakage in the discharge valves in the various stages will be shown by fluctuating receiver pressures. When a pressure rise in any stage results from a small leak, the rise will be gradual and it will be possible to keep the engine operating, although the compressor temperature will be higher than usual, especially at the leaky valve cage; but if the leak is large enough, the pressure will rise rapidly and the relief valve on the affected stage will blow. When this happens, the compressor must be stopped until the defective valve can be repaired. In case an auxiliary compressor is available and it is not desirable to stop the engine, the defective compressor may be cut out by closing the suction to the first stage and operations continued, using air from the auxiliary. The rapidity of pressure rise will offer an indication as to the nature of the trouble, a slow rise indicating leakage due to slightly defective valve seats, dirt under valves, warped valves or defective gaskets and a sudden, rapid rise indicating a broken or stuck valve. When the normal operating temperature has been exceeded, it is well to examine the valve springs at the first opportunity, as the heat will often take all the temper out of the springs and render them ineffective. In most

compressors the valves are contained in cages and seat on the cages, so that destruction of a valve seat does not involve renewal of a compressor cylinder or head. These cages rest on seats in the cylinder or head casting, and a tight joint is made by means of a gasket. These gaskets frequently leak, due to being burned in service or being carelessly put in. Copper or paper makes the best gaskets for these joints, and in general the thinner the gasket the better it will hold. The most satisfactory joint, however, is made by removing the gasket and using a metal-to-metal joint.

The most common cause of valve leakage is carbonized lubricating oil. This forms a hard crust around the valve and on the seat, and in cases where an engine is operating in a dusty atmosphere a large percentage of gritty dirt mingles with this carbon. Most of the lubricating oils used in air compressors are corrosive under operating conditions, and it is not uncommon to find valves that have the appearance of having been etched with acid. This corrosion usually starts at one edge of the valve face and gradually reduces the area of contact between valve and seat, so this action may proceed for quite a long time before contact is broken at any one point and leakage starts.

Most air compressors get too much lubricant, either through too liberal adjustment of lubricators or by inhaling oil from the crankcase. The first can be corrected after the proper amount of oil feed is determined by trial, but the second is not entirely within the control of the operator. If the first-stage cylinder is next to the crankcase, the vacuum in the cylinder during the suction stroke draws some of the oil fog from the crankcase up into the cylinder. In three-stage machines it is customary to place the second-stage cylinder next to the crankcase so that there will always be considerable pressure opposing the entry of oil, but even with this arrangement a surprisingly large amount of oil will work up into the cylinder. As further preventives the piston next to the crankcase should be provided with an oil-scraper ring near its crankcase end and a splash hood should be built around the crank, hugging the connecting rod as closely as possible to prevent oil being thrown from the crank up into the cylinder when near top center.

A part of the oil in the compressor cylinders will be vaporized by the highly heated air and is carried into the intercoolers, where it is condensed and can be blown out through the drains. The part that does not vaporize is carried through the valves and deposited in the air pipes beyond the last stage. If leaky valves or failure of cooling water causes the air temperature to rise, it may get high enough to ignite the air and oil mixture in the pipes and cause a serious explosion. That portion of the oil that is evaporated and recondensed in the intercoolers may not all pass off through the drains; some of it may stick to the tubes in the cooler, and in time the coating of oil on the tubes will seriously reduce the cooling capacity and cause a very high temperature rise in the air. Whenever the engine is shut down for an extensive overhaul, the air compressor and all air piping and tanks should be steamed out if a steam supply is available, or blown out by air. By removing all valves the steam may be passed through the whole system, and if it is left on for at least twenty-four hours a surprising amount of oil can be drained out.

When salt water or water with high acid content is used for cooling, it may sometimes happen that the intercooler tubes will become pitted through and air will be discharged into the water space, stopping the flow of water and causing the compressor to overheat. In the case of vertical engines leakage of air into the cooling water will be shown by a large amount of air collecting in the water-jacket space in the cylinder heads. A check on this is obtained by frequently opening the air cocks on the cylinder heads. The cooling of the air should be carefully watched and it should always be borne in mind that the temperature of the discharge air has a direct relation to the temperature of the suction air. A pretty good indication as to general operative condition of the compressor can be obtained from the thermometer in the discharge line from the compressor. If the temperature here rises above normal, conditions are wrong somewhere and an investigation is in order.

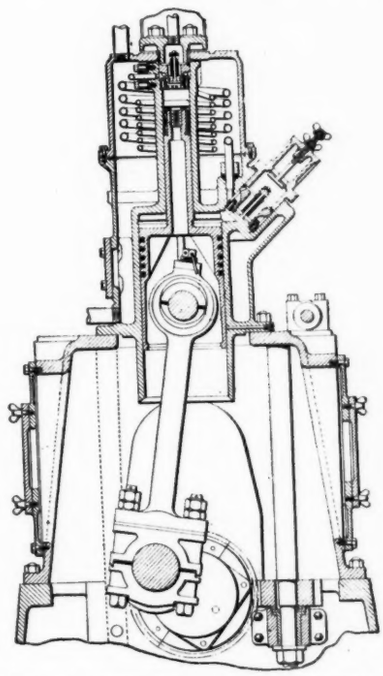


FIG. 2. TWO-STAGE COMPRESSOR FOR SMALL DIESELS

Whenever the compressor bearings have been adjusted, the engine should not be started until the linear clearances of the compressor pistons have been checked. These clearances are sometimes as little as $\frac{1}{32}$ in., and a very slight bearing adjustment will cause a large clearance change.

Whenever the engine is stopped, the discharge valves in the high stage can be quickly tested for tightness by leaving the air line between spray bottles and compressor open and opening the indicator cock on the high-stage cylinder. If air blows through, the discharge valves are leaky. If the indicator cock is closed and the second-stage gage shows pressure, the high-stage suction valves also leak.

The British, who have always given more attention to the gas producer as a source of power than have the Americans, are now giving increased attention to the possibility of using gas producers in motor vehicles, chiefly of the commercial type. With gasoline costing around sixty cents a gallon, attention is naturally turned toward cheaper fuel, such as coal and coke. As far as the fuel cost alone is concerned, the producer-gas-driven outfit could be operated for about one-fifth of the gasoline. However, the cost of fuel is only one element in a very complex problem, so that it would be rather surprising if this method of driving motor vehicles displaced the gasoline explosion motor in the near future.

Water-Power Resources of Canada

Latest Estimates by the Dominion Water Power Branch of the Department of the Interior

DURING the last two years there has been under way in the Dominion Water Power Branch a careful re-analysis and computation of Canada's water-power resources. While the analysis is not yet finally completed, sufficient progress has been made to warrant the publication of the figures given herein. It should be borne in mind, however, that this study is incomplete, as only very meager data are available in many districts and for many rivers.

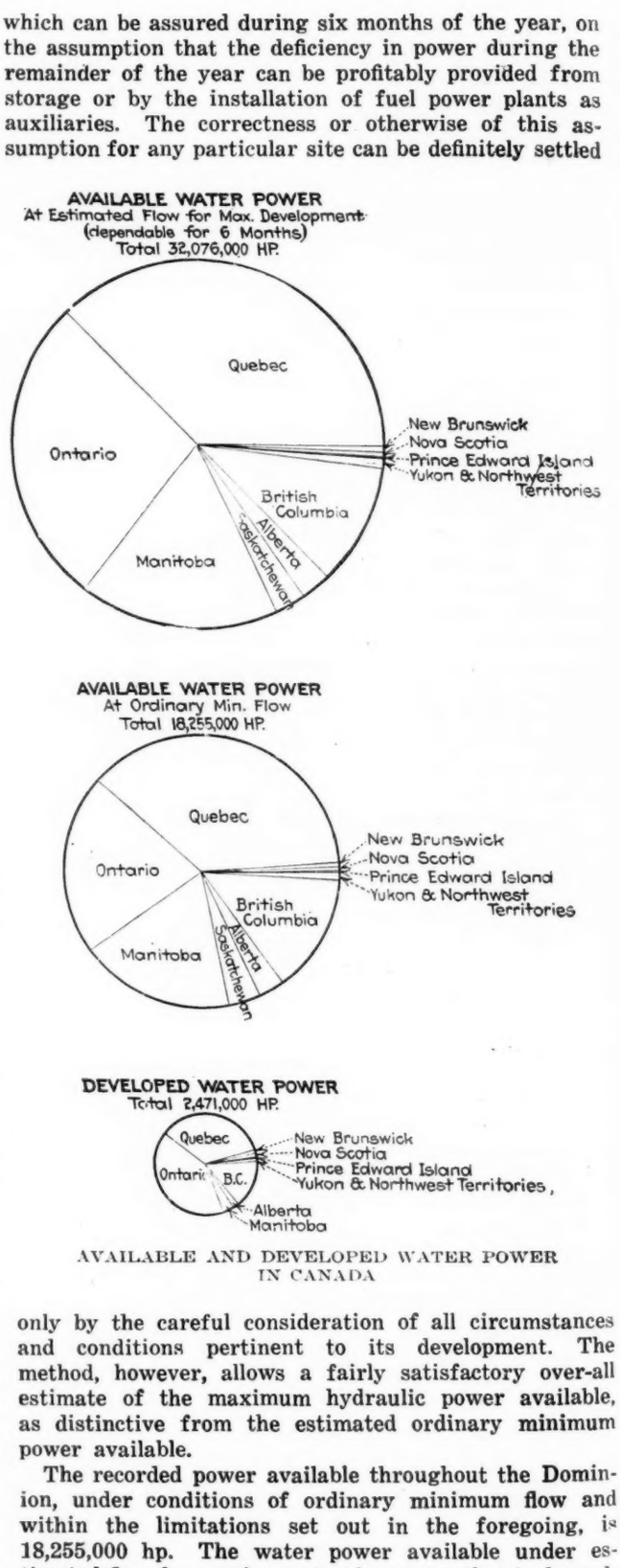
The figures listed in the table and diagram are based on rapids, falls and power sites of which the actual existent drop, or the head possible of concentration, is relatively well known. Innumerable rapids and falls of greater or lesser power capacity are scattered on rivers and streams from coast to coast which are not as yet recorded and will become available for tabulation only as more detailed survey work is undertaken and completed. This is particularly true in the less explored northern districts. Nor is any consideration given to the power concentrations that are feasible

AVAILABLE AND DEVELOPED WATER POWER IN CANADA

Province	Available 24-Hour Power at 80 Per Cent Efficiency At Ordinary Min. Flow, Hp.	At Est. Flow for Max. Dev. (Dependable for 6 Mos.) Hp.	Turbine Installation Hp.
British Columbia	1,931,142	5,103,460	304,535
Alberta	475,281	1,337,505	32,492
Saskatchewan	513,481	1,087,756	.....
Manitoba	3,270,491	5,769,444	83,447
Ontario	4,950,300	6,808,190	1,052,048
Quebec	6,915,244	11,640,052	925,972
New Brunswick	50,406	120,807	21,180
Nova Scotia	20,751	128,264	35,774
Prince Edward Island	3,000	5,276	1 933
Yukon and Northwest Territories	125,220	275,250	13,199
Total	18,255,316	32,075,998	2,470,580

on rivers and streams of gradual gradient, where economic heads may be created by the construction of power dams, excepting at points where definite studies have been carried out and the results made matters of record. In brief, the figures given are based on definite rapids, falls and power sites and may be said to represent the *minimum water-power possibilities* of the Dominion.

The power estimates have been calculated on the basis of 24-hour power at 80 per cent efficiency on the basis of "ordinary minimum flow" and "estimated flow for maximum development." The ordinary minimum flow is based on the averages of the minimum flow for lowest two consecutive seven-day periods in each year, over the period for which records are available The estimated flow for maximum development is based on the continuous power indicated by the flow of the stream for six months in the year. The actual method to determine this flow is to arrange the months of each year according to the day of the lowest flow in each. The lowest of the six high months is taken as the basic month. The average flow of the lowest seven consecutive days in this month determines the maximum for that year. The average of such maximum figures for all years in the period for which data are available is the estimated maximum used in the calculation. This estimated maximum development is based on the assumption that it is good commercial practice to develop wheel installation up to an amount, the continuance of which can be assured during six months of the year, on the assumption that the deficiency in power during the remainder of the year can be profitably provided from storage or by the installation of fuel power plants as auxiliaries. The correctness or otherwise of this assumption for any particular site can be definitely settled



AVAILABLE AND DEVELOPED WATER POWER IN CANADA

only by the careful consideration of all circumstances and conditions pertinent to its development. The method, however, allows a fairly satisfactory over-all estimate of the maximum hydraulic power available, as distinctive from the estimated ordinary minimum power available.

The recorded power available throughout the Dominion, under conditions of ordinary minimum flow and within the limitations set out in the foregoing, is 18,255,000 hp. The water power available under estimated flow for maximum development—that is depend-

able for at least six months of the year—is 32,076,000 hp. There are installed throughout the Dominion waterwheels and turbines to the extent of 2,471,000 hp. However, it would not be correct to place this figure in direct comparison with the minimum or maximum available power figures quoted and therefrom deduce the percentage of the available water-power resources developed to date. An allowance must be made for the average ratio between the waterwheels installed and the power available.

An analysis of the water-power plants scattered from coast to coast, concerning which complete information is available as to turbine installation and satisfactory information as to stream flow, gives an average machine installation 30 per cent greater than the six-months flow maximum power. Applying this, the figures quoted therefore indicate that the at present recorded water-power resources of the Dominion will permit of a turbine installation of 41,700,000 hp. In other words, the present turbine installation represents only 5.9 per cent of the present recorded water-power resources.

Progress During the Last Year

In spite of the outstanding facts that financial and commercial conditions are still far from normal and that costs of construction are almost prohibitive for all but absolutely necessary undertakings, there has been during the last year, and is now, marked activity in water-power development. This has resulted from a variety of causes principal among which is the lack of native coal in the central industrial district and the fortunate location of economic water-power sites to industrial centers.

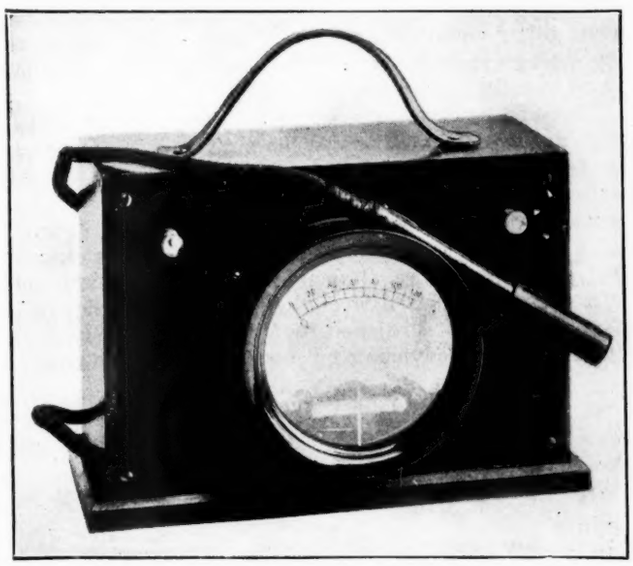
The total water power developed during the last year or now under construction represents approximately 560,000 hp. of installed capacity. This figure includes only the initial installations of plants under construction, not their ultimate designed capacity. It is evidence of the manner in vhich the water-power resources of the Dominion are being put to effective and productive use.

In order to insure the most beneficial utilization of these reserves and to provide intelligent guidance for their development, two essentials are required: First, an accurate knowledge of the location, capacity and the engineering and economic possibilities of development of the water powers throughout the Dominion, together with their relationship to other natural resources of mine and forest, to industrial centers and opportunities, to transportation systems—rail and navigation—to coal and fuel supplies, to irrigation, drainage and reclamation projects, to alternative sources of power and to market for and uses of power in general; secondly, a sound governmental administrative policy designed to protect the public from inadvisable and ill-designed power schemes and to provide for reasonable regulation and revision of rates and rentals, and at the same time to insure satisfactory guarantees for the encouragement of legitimate investment in water-power enterprises.

The water power now developed in Canada represents an investment of $475,000,000. In 1940, should the rate of growth in installation during the last fifteen years be continued, this investment will have grown to over $1,000,000,000. The present development represents an annual equivalent of 18,500,000 tons of coal which, valued at $8 per ton, represents $148,000,000. In the year 1940 these annual figures will, under the foregoing assumption, have become 42,000,000 tons and $336,000,000. These figures are striking evidence of the outstanding importance and necessity of an intelligent administrative policy governing the development of our water-power resources.

Feed-Water Contamination Meter

The majority of large power plants in seaboard cities use salt water for condensing. In practical operation small leaks in condenser tube joints are likely to occur and cause trouble if not promptly detected. Salt leakage accumulates and interferes with proper operation of boilers by causing priming, scale and corrosion. Salt water leaking into feed water deteriorates the boilers, pumps, pipe lines, nozzles and turbines. Philip E. Edelman, 39 Cortlandt St., New York City, has brought out a simple automatic indicator for measuring surface-condenser leakage and boiler-water contamination. Unskilled operators can use it with accurate results.



AUTOMATIC WATER-CONTAMINATION METER

The illustration shows a portable type of instrument. Remote indication can be located in the chief engineer's office as well as in the boiler room.

The electrodes are designed for hot service and may be inserted in the filter box, hotwell, condensate lines or drawn samples. The meter is direct-reading and calibrated in grains per gallon. A particular point, such as 50 grains per gallon, can be set to flash a pilot light to show that the danger point has been reached.

Pure water has an electrical resistance that is very high; by adding common salt or acid the solution becomes a good conductor of electricity. It is upon this simple fact that the operation of this meter is based. Two gold electrodes, in a holder, are placed in the water that it is desired to measure the salt content of. The salt in solution in the water will determine the amount of current that will flow between the electrodes and consequently through the instrument coils. This results in a lower or higher deflection of the needle as the salt content changes. Means are provided for compensating the instrument's readings for changes in the liquid's resistance caused by changes in temperature brought about by variations in pressure. This compensation is obtained by an adjustable resistance in the circuit, which is controlled by the pressure.

Confusion of Engineering Terms

By C. A. Joerger

Undoubtedly, there have been great strides in the knowledge of steam engineering. Yet there is much confusion in the naming and manipulation of the fundamental principles and conceptions. During a recent power-plant test four engineers discussed such items as thermal efficiency, thermodynamic efficiency, Rankine efficiency, engine efficiency, efficiency ratio, etc., and no two had exactly the same conception of any of the terms.

Any committee attempting to standardize these expressions should pay due respect to usage and custom. It is all well and good to say what we ought to do, but if the majority do it differently the way of the majority will be the rule. For example, we all use the expression Corliss engine. No doubt some purist has at some time or other said that our expression was incorrect, that what we should say is, a reciprocating type of steam engine having a Corliss valve gear, or some other equally cumbersome expression. However, we shall go right on saying Corliss engine and we shall know exactly what we mean.

There is, however, a reason for this confusion in that standard works on the subject do not agree on the terms. In fact, it seems almost as though whenever a man writes a book on the subject he deems it necessary to use new symbols and conceptions for old facts.

To illustrate this point of confusion, let us take a few examples. "Let Q denote the heat transformed into work per pound of steam by the actual engine; then if Q_1 is the heat furnished by the boiler per pound of steam, the thermodynamic efficiency of the actual engine is $E_t = \frac{Q}{Q_1}$."[1] The next paragraph states that this is misleading and that "it is customary to define the efficiency as the ratio $\frac{Q}{Q_a}$, where Q_a is the available heat, or the heat that might possibly be transformed under ideal conditions." Now if this second case is the custom, why not use it and stop calling the first case the same name. We have, then, according to the foregoing,

$$E_t = \frac{Q}{Q_1} \text{ or } \frac{Q}{Q_a} \qquad (1)$$

two quantities that are obviously not the same thing.

Then farther on we have: "Where E is the efficiency of the actual engine and E_1 is the efficiency of the ideal cycle, the quantity $\frac{E}{E_1}$ is called the efficiency ratio, E_r."[2] Now what is the difference between this E_r and $E_t = \frac{Q}{Q_a}$ in equation (1)? It is one and the same.

Then again, "The thermal efficiency is found by dividing 2,546.5 by the number of heat units actually consumed per hp.-hr."[3] This looks very much like $\frac{Q}{Q_1}$ in equation (1). So you can show by the handbook that thermodynamic efficiency, efficiency ratio and thermal efficiency may be the same thing. Then we wonder why the confusion. Why use the term efficiency ratio at all? Every expression for efficiency is a ratio. This so-called efficiency ratio is nothing but an efficiency. It is energy got out divided by the energy put in. It is $\frac{Q}{Q_a}$, the heat transformed into work by the actual engine per pound of steam divided by the available heat put in. Now, if it is the custom to call this the Rankine efficiency, what is the objection?

To further illustrate this idea of confusion the following is taken from a textbook: "The term 'thermodynamic efficiency' or 'efficiency' without qualification is ordinarily interpreted as the Rankine cycle ratio, though some authorities apply the name 'thermodynamic efficiency' to the 'thermal efficiency.'" It seems almost that you may call it anything you like.

Another item of confusion is the following. The thermal efficiency of a steam engine or turbine is the ratio of the heat converted into useful work to that supplied, measured above the heat of the liquid at the exhaust-steam temperature. Of course there are some that say the heat supplied should be measured above the actual feed-water temperature. Thermal efficiency may be expressed,

$$E_t = \frac{2{,}546}{W\,(Q_1 - q_n)},$$

when W is the weight of steam supplied in pounds per developed horsepower-hour, Q_1 is the initial heat content, and q_n is the heat of the liquid corresponding to exhaust temperature.

Suppose we have saturated steam with a certain percentage of moisture. How is this to be taken care of in the expression for thermal efficiency? One way is to correct the heat content Q_1. That is, make $Q_1 = x_1 r_1 + q_1$, where x_1 is the dryness factor at initial steam pressure, r_1 is the heat of vaporization at initial steam pressure, and q_1 is the heat of the liquid at initial steam pressure.

Another way is to deduct the moisture from the weight of steam; that is, correct W such that $W' = xW$.

The handbook states that "when the percentage is less than 2 per cent deduct same from the weight of steam. If greater than 2 per cent or if extreme accuracy is required the factor of correction is $1 - \frac{M\,(Q_1 - q_1)}{Q_1 - q}$, in which M is the proportion of moisture, Q_1 and q_1 as above and q the heat in water at feed temperature."

All these various methods may not give large differences, but let us have a standard method.

Take the matter of symbols in steam work. No two men use the same. One author uses Greek letters a great deal, whereas another avoids them. Greek letters should be avoided, as few people could even name the letter. Capital letters and small letters, primes and subscripts are used one way or another by engineers and writers, but rarely alike. Let us have agreement.

The point to the whole matter is that some body such as the A. S. M. E. have a committee such as the Power Test Codes Committee, made up of the greatest men in the field of steam engineering, technical writing and publishing. Let them decide what the standard shall be in each case. Let them decide on a standard steam table with standard symbols. The A. S. M. E. should act as a clearing house and establish the standards. How much easier it would make the quick understanding of the various articles and papers presented at different times. But, as stated in the foregoing, any committee should give due consideration to usage and custom. Its findings and statements should have the same significance to steam engineers that the dictionary does to the writers of English.

[1] "Mechanical Engineers' Handbook," p. 345.
[2] Idem, p. 963.
[3] Idem, p. 1751.

EDITORIALS

Scientific Coal Classification

FOR the first time in the history of the American coal industry the Government has publicly approved a system of coal inspection and classification. This work has been possible through the co-operation of the United States Bureau of Mines with the Sewall's Point Coal Exchange, of Norfolk, Va., and it is a pleasure at this time to congratulate both parties to the co-operation upon the sound basis of coal handling that seems to have been developed.

The advantages of a coal exchange for tidewater transshipment of fuel were well established by war-time experience. That this system of fuel supply has come to stay is well evidenced by the continuance of the exchanges at the various Eastern ports. In the work at Norfolk particularly advantageous results have been attained in the recognition of all parties of interest. In thus recognizing the importance of all parties, this exchange makes the following statement:

> In the efficient performance of its function a coal exchange serves the following interests:
> 1. The consumers (the public) who burn the coal.
> 2. The carriers (railroads and ships) which transport the coal.
> 3. The producers (the operators and employees) who mine the coal.

It is particularly fortunate that the exchange recognizes the interest of the consumer as first, for unless the consumer's interest is made first in any such service agency, continued success cannot be expected.

The inspection and testing of coal shipments and the taking of samples of coal at the mine are two important factors in the establishment of regular and satisfactory coal supply. However, more than mere testing is needed. The interpretation and the use of test results is the important thing. It does little good to analyze every ton of coal unless there be some means of separating good from fair and fair from poor, so that the user may chose that which to him is the most economical, price and quality both considered. The principle that any mine sending coal to this exchange may at any time be shifted from one pool to another is an important recognition of this user interest. If the principle be impartially and vigorously applied, successful results would seem certain, for no one can question the integrity of the coal sampling or analysis that the Federal bureau has done or the soundness of the classification that it has approved.

Coal transferred from car to ship at tidewater represents only a small portion of the industrial fuel supply of the country. Mainly, it is limited to the supply for the New York metropolitan district and New England. For that territory there is great advantage in having effective these various agencies of fuel classification and transshipment. But what of the rest of the country? Is it not possible that some similar agency can be developed that will as well care for the Central West as does this tidewater activity? The present systems of fuel merchandising, especially the activities of the jobbers and wholesalers, are much too elaborately organized to anticipate that they can be immediately superseded by such agency. Nevertheless, it is worth while to consider if there is not need for movement in this direction.

The proposals that have been made for co-operative buying of coal certainly tend that way. Pooling of storage stocks under conditions that permit proper purchase, safe storage and prompt handling to the user is a plan that, for certain conditions at least, has great merit. Until the coal user has some such scheme at his command he remains hopelessly at the mercy of the coal producer and the coal dealer.

Fires in Turbo-Generators

MANY disastrous failures have occurred in large turbine-driven generators, to a considerable portion of which it has been difficult to assign a direct cause. With a generator connected directly to the busbars without any protection, as was general practice up to a few years ago, if a failure did occur in a machine, the damage done practically eliminated all traces of what caused the trouble or where it started. By using differential relay protection, as is now general practice, the machine is disconnected from the line automatically in case of internal trouble and the field circuit opened. This system of protection has greatly reduced the damage done in case of insulation failure of the windings. Failures in generator windings may be due to a direct breakdown of the coil insulation caused by the potential to ground or between coils, or it may be caused by a fire being started in the machine due to some cause that destroys the insulation and results in a breakdown before the machine can be shut down. D. D. Higgins, in the leading article, "Dirt Plus Static as Cause of Turbo-Generator Failures," in this issue, deals with an interesting cause of these fires. From the results of these experiments it is the conclusion that the ignition, by static electrical charges, of the dust that collects on the exposed parts of the coils of the windings may be the cause of some of the fires in turbo-generators to which no particular origin could be attributed.

Unfortunately, the end windings, the weakest part of the coils, is the place where the greatest volume of dirt collects. This, as Mr. Higgins points out, is also where it is most liable to be ignited by static. These end windings are subjected to severe magnetic stresses, and although the parts of the coils are securely braced, it is practically impossible to prevent some movement, which will tend to open up the insulation, and dust particles may penetrate in some cases to such an extent as to cause a failure to ground. When this does occur, all evidence is burned up and the cause may be assigned to a dozen different things and one guess is about as good as another. There are a number of cases on record where industrial motor failures have been caused by carbon and graphite dust working in through the insulation to the copper where the coils bend around the corner of the slots. At first this causes a leak to the frame,

which gradually reduces the insulation to a point where it causes a failure to ground. In a high-voltage machine the potential to ground would cause a failure before the dust worked all the way through the insulation, and the resultant arc would cause a fire that would obliterate all evidence. Mr. Higgins' discussion makes it very clear that if fires are to be prevented in turbo-alternators, there is much more to be given attention than connecting it to an air washer to supply approximately clean air to the machine.

The Efficiency of Internal-Combustion Engines

A LARGE amount of research work has been and is still being made along the line of increasing the thermal efficiency of the internal-combustion engine, especially the oil engine. Taking the Diesel engine as an example, modern designing has enabled a brake-horsepower to be obtained at an expense of 0.38 pound of fuel, a thermal efficiency of thirty-five per cent. In the attempt to secure a further increase in this efficiency, various methods are being advocated. Some investigators are turning their attention toward the problem of compounding in order to secure the heat lost by high exhaust pressures in the standard engine. Compounding involves the question of the action of high exhaust temperatures upon the transfer valve. Other researchers are proceeding along the lines of crank mechanisms which will give an expansion stroke longer than the compression stroke. A modification of this principle is found in the dual-cycle engine. If carried to the extreme, the working cylinder becomes excessively large in dimensions for the power output of the engine.

In Germany much attention is given to the gas turbine in the attempt to secure increased efficiency. As now built, the gas turbine does eliminate many of the early difficulties occasioned by the high gas temperatures. However, the increase in efficiency over that of the Diesel engine does not justify the multiplication of mechanisms required by the gas turbine, although the disadvantage is somewhat offset by the probably lower initial cost of the power plant.

The practical engineer to whom the question of reliability of service is of more concern than is the gain of one per cent or so in efficiency, is likely to question the value of this search for a more efficient internal-combustion machine. Is there not more to be gained in refinements in design which will give additional safeguards against shutdown? The oil engine is so much superior to the most advanced steam plant, the efficiencies being about thirty-five per cent and eighteen per cent, respectively, that any slight gain would affect the ratio but slightly, while probably the reliability of the oil engine would be impaired. The crying need of the internal-combustion engine industry is a means of lowering the manufacturing cost, since the stumbling block to a more general adoption of oil engines is the initial plant cost.

The overhead charge, which depends on the initial cost of the oil-engine plant, is roughly equal to the total operating costs. The fuel cost is around seventy-five per cent of the operating charges. An increase of ten per cent in efficiency or a lowering of fuel charges by some twenty per cent would not be of as much advantage as a reduction of twenty per cent in the initial cost of the plant.

New Fuel Deposits

Recent reports indicate that extensive oil fields as well as coal and shale deposits have been discovered on the Mackenzie River in the Canadian Northwest. According to the report the oil fields are the richest so far discovered on the American continent. This reminds us that probably the world's oil supply is not so limited as some estimates would indicate. There are vast areas of the earth that little or nothing is known of, similar to the Mackenize district, and it may be that these hold undreamed of quantities of oil. Most of these districts are at present difficult of access, but, when the necessity arises, the tremendous wealth that can be made from producing oil wells, will undoubtedly provide the incentive to find what is hidden in these remote districts.

In an emergency everyone who has not schooled himself otherwise is apt to shout advice, instructions or warning. This practice more often than not only adds to the danger of the situation. It is likely to confuse the person or persons in danger rather than to help them avoid the hazard. Clear, quick thinking and a word spoken distinctly but only slightly above the ordinary talking voice will often reach the attention of a hearer and convey the idea intended, when a louder, sharper tone would accomplish just the opposite effect. It is well to be forehanded by planning for every contingency which one can think of as possible to occur in everyday or unusual plant conditions.

The power companies are again being asked to lay in a supply of coal to prevent a coal famine next winter and also to help out the railway and coal operators. Coal shortage should be prevented if possible; however, the means suggested is somewhat one-sided. The power companies are being asked to tie up their capital to help out the railways and coal operators without any reciprocal arrangement on the part of the latter. Why not make it a fifty-fifty proposition and for the use of the capital the railways and coal operator give a lower summer rate to help pay some of the cost of storage. Even if arrangements were made whereby coal and freight charged could be paid on a basis of the amount of coal used per month, this would help to equalize the cost of seasonal storage by the power companies.

The extent to which human effort is being supplemented by electric power is clearly evident in the preliminary statement compiled by the Bureau of the Census, of the electrical manufacturing industry in this country for 1919. According to this statement the value exceeded one billion dollars, an increase of one hundred and eighty three per cent in five years. In the same year electric power was purchased to the amount of nearly eight hundred million dollars. These are big figures, but when considered in the light of what may be achieved with electric power, they represent only a humble beginning.

Discussion on the tariff bill brings out the statement that instead of the shortage and imminent famine which has been offered as the reason for high prices, importations of Mexican oil have permitted the building up of a surplus of approximately twenty-five per cent.

CORRESPONDENCE

Cost of Preparing Pulverized Coal

I read in the July 5 issue of *Power* a short article entitled, "Cost of Preparing Pulverized Coal," referring to the operation of the pulverized-coal plant at the Clarkdale Smelter.

It appears to the writer that any article of this kind that is printed without some explanation is likely to be misleading, particularly to those who are now investigating the possibilities of the use of pulverized coal. It might lead them to believe that the cost of preparing pulverized coal was excessive, whereas in reality in most cases the contrary is the case.

At the Clarkdale Smelter the high cost of preparation is due to the fact that this company uses a submerged coal storage and the costs of unloading, storing and reclaiming the coal from this storage, combined with the high percentage of moisture in this coal as it is taken to the pulverizing plant, are items that, along with the high power and labor costs, are directly responsible for the high cost shown.

Coal has been pulverized on a very economical basis for quite a number of years in the cement industry, where it is recognized that pulverized coal is the cheapest possible fuel to use in the calcining operation, and in order to give some idea as to what can be accomplished in this direction, the following data will be of interest.

At the plant of the Allentown Portland Cement Co., for the entire year of 1919 the total cost of unloading, storing, grinding and conveying coal to the kiln bins was $0.5723 per gross ton, itemized as follows:

Unloading and Storing	$0.1079
Drying	0.0804
Grinding	0.0874
Operating Material	0.0043
Power	0.1790
Maintenance repair labor	0.0368
Miscellaneous repair materials	0.0360
Miscellaneous items	0.0405

As the first item of unloading and storing of $0.1079 is common to any method of handling coal, no mention is usually made of the unloading or storing charge when making comparisons between the burning of pulverized coal and the burning of coal on either hand-fired grates or stokers. Therefore, eliminating this charge, the total cost per gross ton is $0.4643, and per net ton $0.41.

These figures are authentic and are based on an average of 2,976 gross tons per month, or slightly over 100 net tons per day. The actual cost for power charged against this plant was $0.0138c. per kilowatt-hour. No interest, depreciation, insurance or taxes, or what is usually termed overhead, has been included.

The following table gives a general idea as to what the approximate cost for pulverizing would be in plants of different sizes. These figures are based on the present high cost of the installations and on a certain basis for power, labor and coal. The units, however, are given so that the actual cost under any condition can be approximated from the information given in this table.

TABLE SHOWING COST OF PULVERIZING

Daily Capacity in Tons	Cost of Labor, Cents	Number Labor Hours	Repairs, Cents	Drier Fuel, Cents	Power, Cents	Net Cost, Cents	Interest and Depreciation, 12 per Cent, Cents	Total Cost
20	30	12	7	6	12.7	55.7	90	$1.457
30	28	17	7	6	12.7	53.7	60	1.157
40	27.5	22	7	6	12.7	53.2	45	.982
80	20	32	7	6	12.7	45.7	28	.737
160	15.6	50	7	6	12.7	41.3	19.5	.608
240	12.5	60	7	6	12.7	38.2	19.3	.575
320	11	70	7	6	12.7	36.7	18.5	.552
400	10.3	82	7	6	12.7	36	17.4	.534
480	9.7	93	7	6	12.7	35.4	16.6	.52
640	8.2	104	7	6	12.7	33.9	12.1	.460
800	6.75	108	7	6	12.7	32.45	11.8	.4425
960	6	112	7	6	12.7	31.7	11.2	.429
1,120	5.2	116	7	6	12.7	30.9	10.4	.413

This table is based on the following assumed charges: Power, 1c. per kw.-hr.; labor, 50c. per hour; coal for drying, $5 per ton; moisture before drying, 7 per cent. These assumption can be changed to meet given conditions, and the total cost corrected accordingly.

The foregoing does not include transportation to furnaces. H. G. BARNHURST, Advisory Engineer,
New York City. Fuller Engineering Company.

Aligning Engine Shafts

L. Harvey, on page 714 of the May 3 issue of *Power*, asks for the best way to line up his double engine unit and also for an estimate of the time required. I think that my method will meet his requirements very well, and it will require only a small amount of time unless the machines need moving. In that case the time and expense will depend on the difficulty of moving and resetting them.

My first move would be to make the center lines of the shafts meet at the face line of the couplings. Fig. 1 illustrates what I mean. It will be seen that the center lines of the shafts are out of line. To bring them in line is an easy matter, if the flanges are accurately machined, are exactly of the same size and run true on the shaft, by simply applying a scale at various points to their outer surface parallel with the shaft. (See Fig. 2.)

However, if they do not run true or are not the same size, it will be necessary to apply the scale at one point only on the circumference of the coupling.

but with the shaft at different positions in its revolution. Suppose, as in Fig. 3, that the scale when applied to one flange is raised 0.003 in. from the other. Draw line *AB* across both flanges for reference and turn

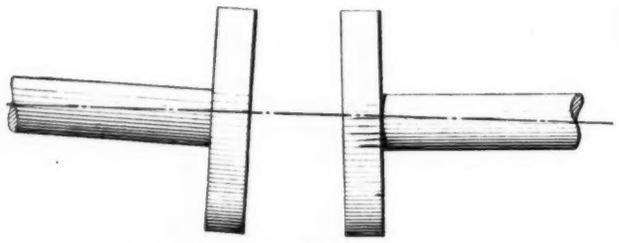


FIG. 1. SHAFTS OUT OF ALIGNMENT

both shafts halfway around. If, in the new position, the measurement is again 0.003 in., the shafts meet correctly on this plane. Do the same with couplings 90 deg. from their former positions, with the line *AB* always registering and the scale applied at the same point on the flange. If the measurements are given

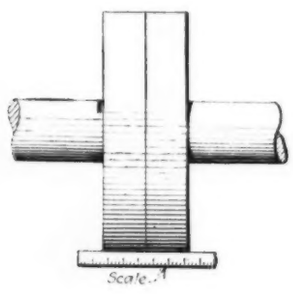


FIG. 2. SAME DIAMETER FLANGES

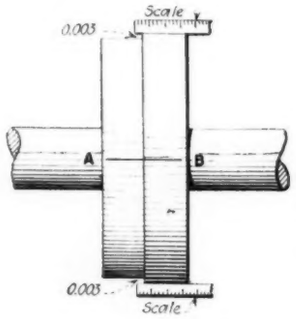


FIG. 3. ODD DIAMETER FLANGES

0.003 in. in both positions, the shafts meet correctly. The flange bolts can then be put in place but not drawn tight.

If the flange faces are accurate, the distance between them will be the same all around when the shafts are in line. This must be determined very accurately with a feeler gage. To test for the accuracy of the flanges as well as for the alignment of the shafts, use the gage as follows: Suppose, as shown in Fig. 4, that the measurements are 0.003 in. and 0.007 in. respectively at *A* and *B*. Then turn the shaft 180 deg. (if the bolts are in place the flanges will move together; if not, use the reference line *AB* as in Fig. 3); and the supposed measurements are 0.002 and 0.006 in. This shows that the couplings have moved 0.001 in. closer together in turning, but are in exact line in this plane, as in either position the flanges will gap 0.004 in. at *B* when *A* touches, and a shim of 0.004 in. will be needed at *B*. In the same way measure at points *A* and *B*, Fig. 5, to determine the accuracy of the flanges and the alignment of the shafts in a horizontal plane.

It is well in all cases to make approximate measurements to see if any large amount of shifting is necessary. If it is desired to determine the amount and direction of shifting that is necessary it can be done in the following manner:

Suppose the measurements were as shown in Fig. 6 and the bearings *C* and *D* were to be left in place. Both shafts would have to be moved at the flange a distance of $23:13::\frac{0.055 \times 12}{2} : x$, or $23:13::0.33:0.186$ in. In the calculation 12 is used because the radius of the flange is 10 in. and the distance between the flange face

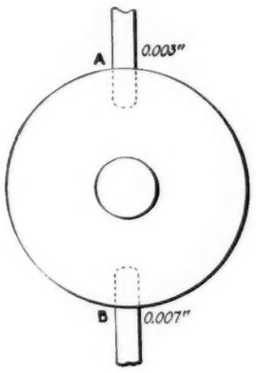


FIG. 4. TESTING WITH GAGE

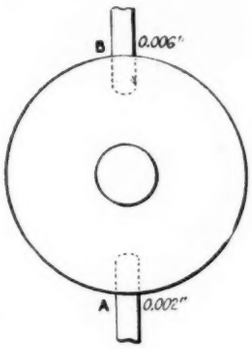


FIG. 5. TESTING AT 180 DEGREES

and the center of the bearing *D* is 120 in., or $120 \div 10 = 12$. Therefore, $0.055 \times 12 \div 2 = 0.33$ in.; or it can be taken another way, or $10:120::0.0275:x$, or $(0.0275 \times 120) \div 10 = 0.33$ in., which is the amount the bearing *D* would have to be moved to bring it in line with the bearing *C*. Therefore the flanges on the engine shaft would have to be moved 0.186 in., as already stated.

To find the amount the bearing *E* must be moved to bring both engine shafts in line, the two end bearings remaining stationary, we have the proportion $13:10::0.186:x$, or $(0.186 \times 10) \div 13 = 0.143$ in. For the bearing *F* we have the proportion $13:15::0.186:x$, or $(0.186 \times 15) \div 13 = 0.214$ in., but as the distance the center of the shaft was moved from the center of the bearing *F* in getting the two shafts in line is $10:24::0.0275:x$, or $(0.0275 \times 24) \div 10 = 0.066$, this must be deducted from the amount shown that the bearing *E* must be moved, or

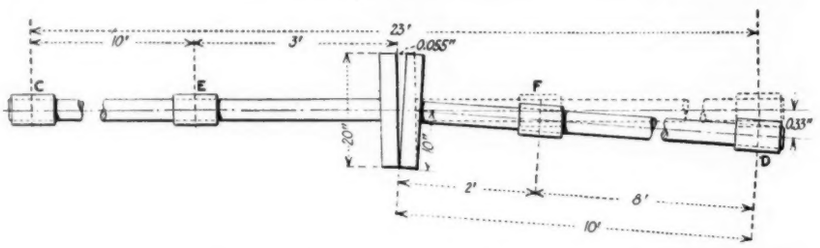


FIG. 6. MEASUREMENTS OF BEARINGS AND SHAFT OUT OF ALIGNMENT

$0.214 - 0.066 = 0.148$ in. The figure 0.0275 is one-half the distance 0.055, which the flanges are open at the top.

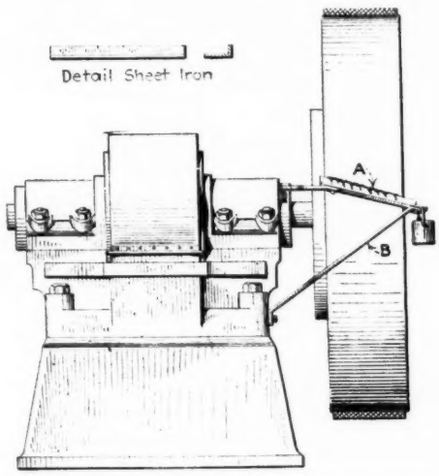
With this method shims, etc., could be provided as required without the cut-and-try plan which is sometimes a very slow method. This method of aligning shafts can be used by anyone familiar with making measurements and will give smooth running even though there are inaccuracies in the flanges or kinks in the shaft ends.

B. E. ECKARD.

Wadsworth, Ohio.

Removing Oil from an Oil-Soaked Belt

Having assumed charge of a power plant using oil engines as prime movers, driving alternators by means of a large three-ply leather belt, and finding that through careless operation and lack of oil guards the belt had become almost hopelessly oil-soaked, I at once got in touch with several belt authorities as to the best way to remove the oil from the belt. Various methods were advised, such as washing with gasoline, applying chalk,



OIL SCRAPER FOR ENGINE FLYWHEEL

etc. However, many of the suggested methods were of questionable value, on account of the fear of spoiling the belt, which had cost considerable money and had been in use only two months. I finally succeeded in removing practically all the oil in the course of a few hours' run by the following means:

A piece of sheet iron of fairly heavy weight was obtained and shaped as shown, and mounted on a temporary holder that was fastened to the engine frame so as to hold it in a diagonal position against the face of the flywheel. The part in contact with the flywheel soon ground down to a knife edge, and it was found that the oil deposited on the face of the flywheel was skimmed off. To our surprise this skimming effect continued until the oil in the belt was practically all extracted. It seems that the mutual capillary attraction of the oil and the continual clean face of the flywheel keeps the oil coming out, or perhaps some of *Power's* readers can offer a better explanation.

Polson, Mont. DUANE TROW.

Progress in Pump Design

Referring to page 995 of the June 21 issue of *Power* regarding "Sixty Years Progress in Pumps," the subject of future progress in pump design will give more consideration to the following:

1. Local pressures and resistances in pumps, in supply and discharge lines, such as bends, etc. Recording machines on present pumps would materially help to improve design.

2. Lubrication at the correct points on bearing, etc. Much of the present-day lubrication is not correctly placed.

3. The pressures, flow, clearance, etc., now receiving attention will of course be improved as to regulation and economy of operation.

I wish in the foregoing to point out the subjects neglected by many designers and manufacturers. More publicity along educational lines in terms that users can understand would result in many replacement orders for better pumps, where the economies effected would, in a reasonable time, pay for the cost of the improvements.

Ardmore, Pa. ARCHER G. DEAN.

Improved the Governor Control

Considerable governor trouble has been experienced in the operation of two old-type turbines, one driving the hotwell pump, the other a circulating pump. The governor failed to control the turbine on account of rapid and excessive wear to the contact parts, and the resulting chatter wore out the connection between the valve stem and its seat.

Fig. 1 shows the construction as originally furnished with the turbine. The governor pin on this type has a maximum travel of ⅜ in., seemingly giving the valve the same travel. However, owing to unavoidable lost motion, it was impossible to get more than ⅛ in. travel on the governor valve when the governor was new. The rapid wear still further and seriously reduced this

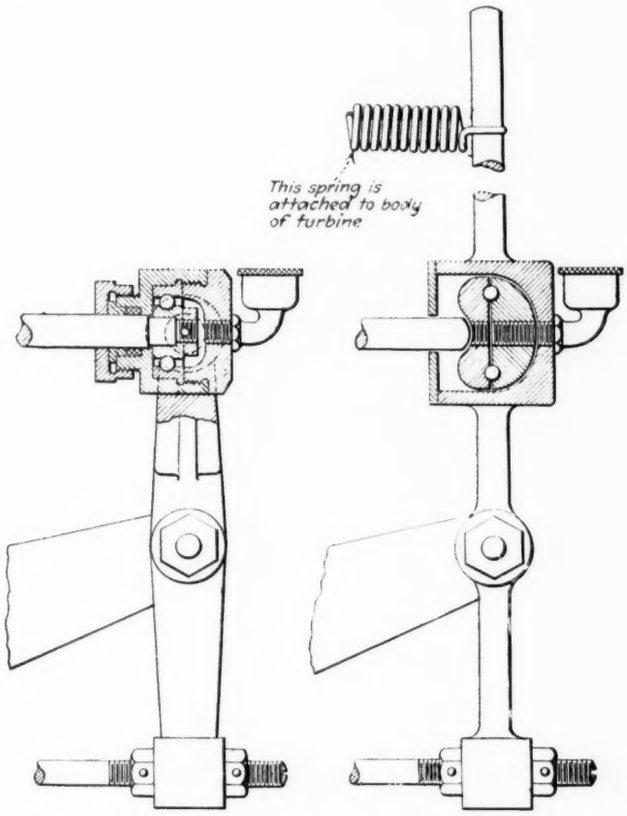


FIG. 1. OLD CONSTRUCTION FIG. 2. NEW DESIGN

travel, and the governor valve, after a short period of operation, allowed the turbine to hunt. It was found that the seat of the trouble lay in the rigid connection of the governor spindle to the pivot block and governor lever.

Fig. 2 shows the construction that was devised and adopted and which has proved entirely satisfactory in operation.

Springfield, Ohio. T. N. LYTTLE.

Economical Operating Limits of the Refillable Fuse

The article in the July 19 issue, page 105, on "Economical Operating Limits of the Refillable Fuse," by Mr. Jones, presents the proper method to attack the fuse-cost problem. He had not taken into consideration, however, the life of the refillable fuse.

Under perfect operating conditions, where there is a renewal perhaps once a year, the life is indefinite; but on circuits where renewals must be made at the rate of, say, ten per year, it has been the writer's experience that the fuses will not last the year out. The reason is that the attendants re-fill them with grimy or oily hands or in other ways are careless about making a cool contact between blade and refill, with the result that the fuse and holder heat excessively. This heat oxidizes the fuse and its clips, which further increases the contact resistance. The heat also takes the spring out of the clips so that they must be replaced. After a fuse has been refilled a few times, owing to the combined heating effect of poor contact and load, the attendant often doubles the refill, which in turn reduces the protection afforded the apparatus. This further promotes heating, so that in the type of refillable fuse that I have handled, the fiber cylinder chars away at the ends where it is threaded for the ferrule or blades, thus exposing the fuse wire and making it difficult and dangerous to remove or replace. Also when the refill does melt, it spatters around.

With these objections to the refillable fuse in mind —(1) short life, (2) excessive heating, (3) danger to attendant and apparatus, (4) replacement of overheated holders—the cost will be found to depend largely upon the character of the load it protects.

Stratford, Conn. HORACE STEINHOFF.

Opening and Closing the Blowoff

Referring to the item on opening and closing blowoff, page 1067 of the June 28 issue, regarding the method of operating a double blowoff combination, in our estimation the answer that should have been given is to the effect that in blowing down a boiler the cock should be opened first and then the valve; while in closing off, the valve should be closed first and then the cock.

This method seems to be standard practice in the leading power plants and is the one that we recommend to purchasers of our combination blowoff valve. Our reasons for such recommendation are based on the following consideration:

It is essential to have at least one good blowoff valve on the line, to eliminate the necessity of shutting down the boiler when making repair to the other valve. For this reason, when the blowoff valves are operated in the manner described, the wear and tear will take place on the seat and the disc of the blowoff valve, which could be taken apart and either reversed or repaired, as the case might be, by simply closing the quarter-turn valve, which would hold the pressure until such time as the angle valve could be again installed on the line. It will be understood, of course, that opening and closing the quarter-turn valve in practically still water would tend to lengthen the life of this valve materially and would insure at least one tight valve on the blowoff line. Following out the foregoing suggestion would, in addition, eliminate any chance of water hammer at the time of blowing down the boiler. This would especially hold true in the case of large boilers carrying heavy pressures. S. I. FINK,

Homestead Valve Manufacturing Co.

Homestead, Pa.

[There seams to be a considerable difference of opinion in the matter, as indicated by the following from the report of the Prime Movers' Committee at the recent meeting of the National Electric Light Association:

Present practice varies greatly with regard to blow-off valves if replies to a questionnaire by twenty members of the committee, all operators of large central stations, may be taken as a fair basis for conclusion. This entire lack of uniformity is noted not only in the type of valve used, but in methods of installation and order of operation.

A common arrangement reported is a quick-opening valve of the Everlasting or a plug-cock type, together with an angle valve, as, for example, the Simplex. Fourteen out of the twenty committee members used this general arrangement, and seven of these used plug cocks for the quick-opening valve, but whether the quick-opening valve should be located ahead of or behind the angle valve is a point on which opinion is about equally divided. The manufacturers of blowoff valves usually recommend that the valve serving as the actual blowoff valve should be located farthest from the boiler.

A rather surprising difference in practice is noted with regard to the order of operation where a valve of the quick-opening type is used in connection with an angle valve. Five operators out of fourteen open the angle valve and blow down with the Everlasting or plug-cock type. The thought undoubtedly is that by using this method the angle valve is more easily kept tight. The reverse, however, is the more logical and generally accepted method.

What is the practice of our readers and why?—Editor.]

Rupturing of Welded Fire Sheets

Referring to page 999 of the June 21 issue, on which is described the rupture of a locomotive-type firebox side sheet, I would say that this is not an unusual occurrence in locomotive fireboxes of the narrow type, in which the side sheets frequently corrugate badly in the center of the sheets above the grate line. After a period of service, depending on the quality of the water, cracks will appear around the staybolts on the fire side. Bulging will occur between the vertical rows of staybolts, toward the fire, and even when nothing is visible on the fire side, cracks exist on the water side, finally letting go as described. This happened on the road in one case I recall, and while examining the side sheet after the engine had been towed into the shop, a hammer being used for the purpose, the crack extended about 18 in. more.

It was clearly shown by a committee of the Master Mechanics Association that in service the water left the side sheets in these locomotives, and of course the sheet, having nothing but steam against it, became overheated and gradually deteriorated.

As far as danger is concerned, I have never known of anything happening in one of these cases, except that the water going into the firebox put out the fire.

The welding in the case quoted was doubtless done because of a defect in the sheet, possibly a part of the crack having broken through there. But it would be impossible for the welding heat to affect the sheet at any such distance from the weld as shown by the crack. It would be instructive to have further particulars.

Rochester, N. Y. S. W. MILLER.

Breaking In the Green Man

Americanization is a good thing, but not much attention is paid to it until it is necessary, as it sometimes happens, to place a foreigner on in place of some of the regular crew. For example, there are a number of foreigners in the coal- or ash-handling crews and one of the regular firemen quits or does not report for duty. The most likely looking chap is taken from the bunch to be broken in as a fireman. Up to this time very little attention has been paid to him so long as he reported for work daily. When he is instructed in his duties as a fireman, it is done as quickly as possible, and he is watched for a few minutes to see if he remembers anything that has been told him. He is then perhaps forgotten by those who should see that he is always progressing instead of getting in a rut and staying there.

There is not much a person would want to do around a power plant if he did not understand why it was done. To the green man everything looks big, complicated, and a pile of coal that is biggest of all is right before him. His first thought is that this pile of coal has got to be burned; it is his job to do it; all he has to do is to shovel it into the furnace and burn it up; and the more he puts in at one time, the sooner it will be burned.

He probably understands but little of the language the men around him are using. One tells him to do this and another tells him to do that, but not a word of why he is to do it or why he is to do it that particular way. Of course he will do it because he is new and wishes to make a good impression, but that is about all. The other men take it for granted that he understands and he is not going to admit that he does not.

This is where a good teacher is a valuable asset to have around the plant, and such a man is a rarity. A good teacher is one who can get his ideas across to the other fellow so that he knows the other fellow understands.

Simple Explanations Necessary

It is a mistake to believe it is not up to engineers to help the green man along just because there is an Americanization class conducted in the factory for those who wish to attend. It is almost certain that any man, if he is conscientious, will listen to what one has to say, but one cannot expect to get much response from him by soaring away up over his head, telling him things he did not know existed. It is necessary to get down to the language the man understands and to use as few technical terms as possible. If a thing cannot be explained without the use of technical terms, it is too far advanced for the man being instructed and some other way must be used to get the message across to him.

Go into the boiler room and start a conversation regarding some piece of equipment, and when an inquiry for information is forthcoming, explain it so that the man can understand it. If one takes a new man and endeavors to make a fireman out of him and does not make sure that he understands what is told him, he is not getting a square show. Give him his instructions hurriedly or not in detail, and he is quick to notice it and is not impressed with their importance, and does not pay the attention to them that he should and soon forgets them.

It frequently happens that one takes a green man and tells him to weigh all the coal he brings out and enter it on the tally sheet on the scales, but does not tell him why it is weighed or entered, and naturally enough he shows little interest in the work. He is told to keep a thin even fire on the grates but not why; he will probably do it for a short time until the novelty of the new job has worn off. He will then need to have something else to hold his interest on the job.

When a man is told to weigh the coal, take a few minutes and find out if he has any idea why it is to be weighed. If he has not, tell him that it is necessary to know the amount of coal that is burned each day or shift so that a complete daily log or report sheet can be kept and that all calculations depend primarily on the accuracy with which he keeps the record of coal used. Show him that the evaporation per pound of coal and all the data are obtained from his coal record and that it must come accurate from him if there is to be any degree of accuracy in the daily report. It will pay to be sure the man understands this part of his work. It will show him that his part is really necessary, and if he understands that he has something to do toward helping to find out a few things, he will be more interested and conscientious in doing his part.

Records Will Assist Firemen

A poorly kept or inaccurate record is little better than no record at all; one would not take much stock in a record of some other fellow if it was thought to be about all estimated. Such records are worthless. Tell the man why the water is metered; do not let him get the idea that it is to check him up in his work, but show him that it is to make it lighter if possible by checking up the boiler; that the coal might not be as good as usual, etc., and this is one of the ways for discovering it; that it is not to check him on his ability as a fireman, but to make him a better fireman and make his work as easy as possible.

Then there is the damper regulator or damper. Perhaps he did not know there was such a thing. Show him how to calibrate the damper by means of the draft gage and the correct way to set the damper after he has calibrated it. One cannot expect the fireman to show much ambition when it is such a hard matter to get some engineers even to use the damper; therefore a little time is well spent in teaching.

Some engineers and firemen are timid about opening the blowoff valve on a boiler when blowing down. Of course it is supposed to be opened wide for a few minutes if it is expected to get any benefit from blowing down. One day I happened to be watching an engineer blowing down his boilers and noticed that he opened the valve about one-quarter. I asked him if he didn't think he would get more benefit from the operation if it was opened all the way? He replied, "I should say not; that would be liable to blow the bonnet off the valve." This man was in fear of the blowoff valve until it was explained to him. Some firemen do not think a combustion chamber should be cleaned out oftener than every six or eight weeks. The excuse is that it cannot be done and that it is too hot to handle. Of course it is a disagreeable job, but it cannot be avoided and the easiest way is to keep it clean.

There are any number of pieces of apparatus in a power plant that are not thoroughly understood, and it is a good idea to take one up for discussion for a few minutes each day. Engineers and firemen seldom go through a set time of apprenticeship, and many a man is liable to start engineering who is not willing to put time and effort into acquiring the right sort of training at the start.

Many a man has thought the chief engineer a funny fellow because the chief never let him construct or repair some instrument; he has doubtless forgotten the faulty manner in which he has handled some other problem, and perhaps the chief has lost heart in trying to put opportunities in his path. There are other men who will say of their chief, "He is the best man I ever worked under." They deserve a good share of the credit in that case, because they no doubt showed some disposition to do things and the chief gave them the opportunity to work out problems on their own hook.

If the man who is trying to come up in the power plant is worth teaching at all he is worth teaching right, and the point is to be sure to begin right. Do not attempt to teach him something not understood yourself. Master it yourself, then spring it on him. If someone else is delegated to this work, be sure that he has the right ideas. A man who is delegated to break in new men must be loyal to the plant and to the chief, not a knocker, and unselfish. If a man is broken in properly, he will be the best booster you can get.

I believe it is a good plan to tell the men what is going on in the plant, how things are holding out and all the general details in which they have any interest.

Rochester, N. Y. C. M. BOURCY.

Influence of Irregularities in Boiler Feed

The question of suitable regulation of the rate of feeding water to boilers is pertinent to every fireman, as affecting economy of steam, water and fuel. The losses that will occur, due to irregularities in the feed because of carelessness and inattention, may amount to an alarming total when the heat lost by water blown down, steam from popping safety valves, and excessive fuel fired, is calculated.

In every boiler the heating surfaces are so designed that at a certain level of the water in the drum the most efficient operation and heat transfer will occur. Too high a water level in the drum may cause priming, and excessive moisture in the steam, which results not only in a decrease in the efficiency of all steam-driven apparatus, but also in an excessive use of water. On the other hand, too low a water level may result in the danger of damaging the heating surfaces, with the possibility of a disastrous explosion due to sudden fracture of such metal. In fire-tube boilers this is partly guarded against by the use of fusible plugs.

To operate most economically and efficiently, the boiler water must be maintained at as nearly a constant level as possible. In general this level is designed for at about the center of the gage glass, or the equivalent to two gages.

The argument may be advanced that in the "one-fireman boiler house," as in many smaller plants burning fuel oil, it will be too much of a job for the operater to pay the proper attention to his feed pumps in order to keep a constant water level. This may be true if the plant is subject to sudden, widely varying loads, but if it is a normally operating boiler plant, as is generally the case, subject to certain periodic peak loads, the fireman will be able to devote the necessary time to regulate the pumps.

Perhaps the most wasteful result of careless boiler-feed regulation is the necessity for more frequent blowdown than is requisite in good operation. For example, the fireman allows his water level to drop too low through inattention. Forthwith, he opens up wider on the feed pump to increase the feed. Normally, he will not take into account that it requires but a few minutes to bring the water level back to normal, and the first thing he knows the water level is nearly at the top of the gage glass. Then he slows down the pumps, generally more than necessary, and promptly blows the boiler down until the required water level is reached. The ultimate result of this careless and common practice is that a waste of heat occurs in additional fuel being required to heat the excess cold water pumped to the boiler when the pump was working too fast, it then being thrown away in the hot water blown out of the boiler when reducing the level.

Nor is the foregoing the only example of waste, for a certain amount of water has probably been blown into the sewer. If the plant purchases and treats its boiler water, the meter will show a greater consumption than actually used for conversion into steam, and consequently the pounds of water calculated as being evaporated per pound of fuel will be higher than actual, and a heavier load will be indicated. It is evident that a direct loss is incurred by the plant, which, if calculated in the cash value of the steam developed, would exceed the fireman's daily wage several times over.

The final remedy, if instructions have no effect in bringing the fireman to a realization that he must use more care and attention and thereby save himself work in the regulation of his boiler-feed water, is to install a recording pressure gage on the main blowdown line. The charts of such a gage should be changed daily and sent to the chief engineer or superintendent, who can read at a glance the number of times the boilers were blown down and the extent of each blowdown, and on which shift they occurred.

In marine practice instructions, particularly naval, under which efficient water tending in boilers is carried out, are insisted upon. Although they are not recommended in detail for stationary operation, a knowledge of their ultimate purpose and a partial or entire adherence thereto, will aid the stationary operator.

Blow thoroughly all gage glasses hourly or more frequently if considered necessary; test gage cocks hourly; should the water level in the boiler drop out of sight and below the lowest gage cock, it is the safest practice to shut off the fire, if an oil burner, or extinguish and pull the fire, if coal is used. This is a "safety first" precaution, since the fireman cannot tell to what low level the water has dropped. Thereby he may save serious distortion of heating surfaces, destruction of brickwork, leaks and possible boiler explosion.

If the water has dropped beyond a testing level, it is "safety first" not to try to restore it by speeding up the pumps. Rather, extinguish the fires and allow the boiler to cool down to a safe degree before bringing the water level back to normal and firing up again; as long as a boiler is under fire and furnishing steam, never entirely close off the water supply; at regular intervals inspect the gage glasses and cocks to be sure that the connections from the boiler drums thereto are clear and that the water has an uninterrupted flow. Repair leaky or broken gage glasses or connections immediately; in installing gage glasses, make sure that they are in line at the connections, to avoid undue strain on the glass, which may cause it to fracture.

Port Arthur, Tex. ALLEN F. BREWER.

INQUIRIES OF GENERAL INTEREST

Joint Efficiency with Plates of Different Thickness—When a riveted lap joint is made by riveting together plates of different thicknesses, should the efficiency of joint be based on the strength of the thicker or the thinner plate?

J. M. W.

The strength of the joint with respect to strength of plate between rivet holes would depend on the strength of the thinner plate, and the efficiency of joint referred to solid plate would be taken with respect to the thinner plate.

Coal Value Depends on More Than Ash and B.t.u.—Which would be the more economical to purchase, coal having 13,000 B.t.u. per pound and 17 per cent ash costing $2.75 per ton of 2,000 lb. laid in the boiler room, or a coal containing 14,000 B.t.u. per pound with 8 per cent ash costing $4 per ton of 2,000 lb. laid in the boiler room? C. M.

The relative economy is not susceptible of solution on a basis of heat per dollar, for in each case the cost of handling the coal, stoking, handling ashes and clinker, the percentage of combustible in the refuse and cost of furnace repairs would depend on the characteristics of the fuel and the facilities and management of the plant.

Ammonia-Compressor Cooling Jacket—Why are not ammonia-compressor cooling jackets made the entire length of the cylinder instead of merely extending down halfway?

G. G.

The temperature of the ingoing-jacket cooling water is never lower than 60 deg. F. The suction vapor is always below this value, say zero degrees. If the jacket extended the entire length of the cylinder, the suction gas after entering the cylinder would actually absorb heat from the jacket due to the 60-deg. temperature difference. As the piston compresses the ammonia vapor, it warms up and reaches 60-deg. temperature around one half-stroke. By starting the cooling jacket at this point, the jacket water will then absorb heat from the gas during the remainder of the stroke, where the work of compression increases the temperature of the gas much above 60 degrees.

Increasing Feed-Water Temperature and Back Pressure—For the purpose of raising the temperature of the boiler-feed water from 180 to 200 deg. F. in a closed exhaust-steam feed-water heater, and steam used only for the engine, would it pay to increase the present 2 lb. back pressure to 3 lb. on a 22 x 42-in. non-condensing engine running 90 r.p.m. and developing 250 i.hp. with steam at 100 lb. boiler pressure? H. A. L.

The horsepower constant of the engine, or power developed per pound mean effective pressure, is

$$\frac{(22 \times 22 \times 0.7854) \times 42 \times 90 \times 2}{12 \times 33{,}000} = 7.257 \; i.hp.$$

per pound m.e.p., and each pound additional back pressure would require $\frac{7.257}{250}$ i.hp., or about 2.9 per cent, more steam to be supplied to the engine at the present pressure for developing the present power; that is, there must be 1.029 times as much heat supplied.

Each pound of dry saturated steam supplied at 100 lb. gage pressure contains 1,188.8 B.t.u. above 32 deg. F., and with the feed water at 180 deg. F., the boiler supplies (1,188.8 + 32) — 180 = 1,040.8 B.t.u. per pound of steam used. With the feed-water temperature 200 instead of 180 deg. F., for each pound of steam generated the boiler would need to supply 20 B.t.u. less, or 1,048.8 — 20 = 1,020.8 B.t.u. But as 1.029 times as much steam would be required, the boiler would have to furnish $\frac{1{,}020.8}{1{,}040.8} \times 1.029 = 1.009$ times as much heat; that is, about 1 per cent more fuel would be required. Hence under the conditions stated it would not pay to increase the feed-water temperature at the expense of increasing back pressure unless by so doing the exhaust is made available for purposes, like heating, that otherwise would require over 1 per cent as much live steam as now supplied to the engine.

Exciting Systems—What is current practice respecting the use of shunt and compound direct-current generators as exciters, singly or several units in parallel, with and without Tirrell voltage regulators? M. E. A.

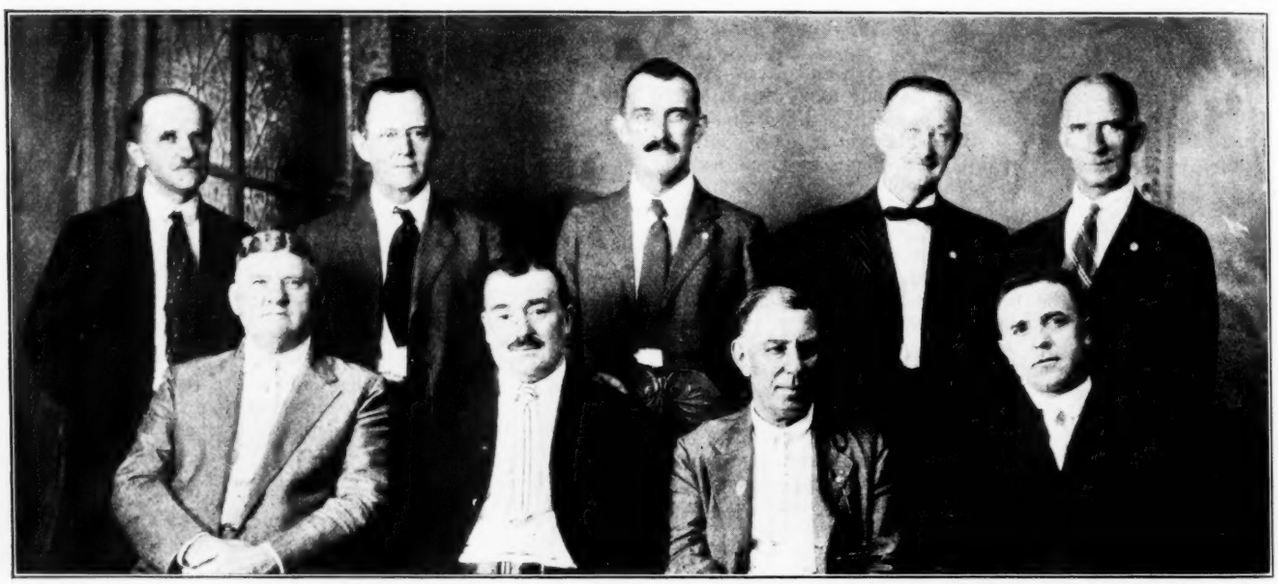
There are two main systems to be found in central stations for the excitation of alternating-current generators. In the so-called common-exciter system, the plant is provided with a central exciting plant composed of two or more direct-current generators operating in parallel, which supply exciting current to all the main units through a common exciter bus. The exciting generators are generally compound-wound and flat compounded, to maintain a constant exciter-bus voltage. The central exciting plant may include a storage battery as a stand-by. The field current of the main units is sometimes controlled by automatic adjustment of the field rheostat. This system has been almost entirely superseded in modern stations by the so-called individual-exciter system, in which each main generator is equipped with a separate exciter that supplies that unit and no other. Therefore they are seldom operated in parallel. The exciter may be mounted directly on the end of the shaft of the main unit, driven by a motor, by a steam turbine or by both, in case of duplex drive. It may be shunt or compound-wound. This system has the advantage of allowing the use of Tirrell voltage regulators, which control the voltage of the main unit by varying the field strength of the exciter. It also reduces the length of the large field leads. The Tirrell regulator connected across the exciter shunt field gives much more flexibility and speed of control than any method of adjustment of the main field, owing to the large currents and heavy moving parts involved in the latter. Some stations are equipped with both central and individual exciter systems, a storage battery and charging equipment being provided as a stand-by to the individual exciters. A third exciting system is being tried out in Sweden, which is a combination of the two. A central exciting plant and exciter bus are provided to supply all the main generator fields, but each main unit is equipped with an individual booster exciter which replaces the field rheostat, the main field and booster being connected in series across the exciter bus. The booster field is controlled to make the individual exciter voltage boost or buck that of the exciter bus.

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communication and for the inquiries to receive attention.—Editor.]

N. A. S. E. To Convene at Evansville

FOR the third time Evansville, Ind., is to have the annual convention of the National Association of Stationary Engineers. The last convention held in this city in 1917 is so recent that memory of its success is still fresh, and the prospects are that local No. 7 will even exceed the record of four years ago. Most of the committee serving at that time are again in the harness; the Coliseum, an excellent place for the exhibits and the business meetings, will be available; headquarters will be at Hotel McCurdy, and the field-day sports will be held at Bosse Field in Garvin Park. All the way through the arrangements are ideal, and the setting is now being laid for the one best convention. The date is Sept. 12-16, inclusive.

As in previous years a fair proportion of convention time is to be devoted to papers and educational work. The local convention executive committee consists of Charles Streithof, general chairman; E. G. Heeger, vice-chairman and chairman of entertainment committee; Carl Dreisch, secretary and chairman of the publicity committee; Gus Weber, financial secretary and chairman of hotels committee; Carl G. Brunner, treasurer and chairman of transportation and automobile committee; William Baechle, chairman of field-day committee; Louis Minke, chairman of exhibition committee; Henry Welz, chairman of ladies' entertainment committee, and Charles Boos. Of an advisory committee backing the efforts of the engineers and co-operating with them, Mayor Bosse is chairman. The program in detail follows:



LOCAL CONVENTION COMMITTEE, NATIONAL ASSOCIATION OF STATIONARY ENGINEERS
Left to Right: Front Row—G. C. Bruner, W. G. Baechle, E. G. Heegar, Carl Dreisch, Back Row—Henry Welz, Gustav Weber, Charles Streithof, Louis Minke, Charles Boos.

Monday, Sept. 12, the local reception committee will meet delegates and visitors at all trains, escorting them to hotels and registration headquarters. Official registration will take place at the exposition hall, Memorial Coliseum, from 9 a.m. to 9 p.m. At 8 p.m. the mechanical exposition will be officially opened with addresses by F. N. Chapman, president of the National Exhibitors' Association; Alfred Johnson, president of the National Association of Stationary Engineers; Henry Kleymeyer, president of the Evansville Chamber of Commerce, and by J. J. Morris, president of Evansville Manufacturers' Association. From 10 to 12 p.m. there will be an informal reception by the national officers and a dance at headquarters, Hotel McCurdy.

Tuesday, Sept. 13, 9 a.m., those attending the convention will assemble at Hotel McCurdy and march to the Coliseum for the opening session, at which Charles Streithof, chairman of the local convention committee, will preside. Addresses of welcome will be delivered by Governor W. H. McCray, Mayor Benjamin Bosse and James R. Duncan, of the Evansville Chamber of Commerce. The responses will be made by National President Alfred Johnson, Vice-President Richard W. Parry and J. J. Callahan, past national president. After the preliminary addresses President Johnson will officially open the convention and appoint the usual committees. The official convention photograph will be taken in front of the Coliseum at the close of the session. At 2 p.m. the first business session of the convention will be held in the Knights of Columbus Hall across from the Coliseum. The opening session of the Ladies' National Auxiliary will take place at the same time on the second floor of the Coliseum. At 3 p.m. there will be a paper on "Modern Passenger Elevators," by W. E. Cory, and at 4 p.m. the annual meeting of the Life and Accident department. At 8 p.m. a theater party is planned for the ladies.

Wednesday, Sept. 14, will be manufacturers' and employers' day at the mechanical exposition. The second business session of the convention will open at 9:30 a.m. and an hour later Henry Kreisinger, in a paper on the "Bureau of Mines," will tell what it has done for the power-plant engineer and how it has been accomplished. There will be an auto trip for the ladies at 11 a.m. to points about the city and along the river front, with a stop en route for luncheon, returning to Bosse Field Stadium for the annual field sports and ball games, where they will be joined by the engineers and exhibitors. At 9 p.m. the National Exhibitors' Association will entertain.

Thursday, Sept. 15, 9:30 a.m., business session of the convention with a paper at 10 a.m., on "Poppet-Valve and Unaflow Engines," by George A. Cooper. At the fourth business session at 1:30 p.m., John W. Lane, editor of the *National Engineer*, will introduce the topical discussion "Being Known in Your Own Town." At 4 p.m. there will be a steamboat ride on the Ohio River, with luncheon and refreshments served on the boat, dancing and a general good time, followed at 8 p.m. by the annual entertainment under the auspices of the National Exhibitors' Association in the Memorial Coliseum.

Friday, Sept. 16, 9:30 a.m., business session of the convention and final session of the Ladies' National Auxiliary, election of officers, selection of next convention city and disbursement of mileage; 9 p.m., public installation of officers of the N. A. S. E. and grand concert and ball.

Reciprocating Pumping Engines and Turbo-Centrifugal Pumps*

By HUGH LUPTON

THE principal points that the water-works engineer considers in the selection of a plant are arranged in the following order of importance: (1) Reliability; (2) running costs, which include fuel consumption and, therefore, thermal and mechanical efficiency in actual work; (3) capital cost.

1. Reliability—It is natural to expect that the reciprocating engine would in this respect have the advantage. The usual speed of a reciprocating pumping engine operating plunger pumps is from 30 r.p.m. to 40 r.p.m., or a piston speed from 180 ft. to 280 ft. a minute, while insomuch as the blade of a steam turbine, if it is to work efficiently, must bear a ratio to that of the impinging steam, therefore the number of revolutions per minute is necessarily high. It will be found that the lowest number of revolutions of the steam portion of the plant will not be less than 3,000 per min., while speeds up to over 10,000 are in common use. The turbine pump, the peripheral speed of which in feet per second approximates eight times the square root of the head in feet pumped against per stage, also runs at a comparatively high velocity, though considerably less than that of the steam end of the plant, necessitating the use of reduction gear between the two. It would, therefore, be expected that a reciprocating engine would have the advantage in durability, and this seems to be borne out by experience.

The durability of the reciprocating pumping engine is well known and hardly needs exemplifying, but I may just mention that a triple vertical supplied to the Bristol water-works in 1914, and which has been at work constantly since that date, having pumped 7,600,000,000 gal. against a head of 210 ft., used on its initial trial made in 1914, 12.37 lb. of steam per pump horsepower-hour ascertained from pump displacement, and when again tested in January of this year, was found to be using 12.6 lb. of steam, or practically the same amount. In this connection it may be mentioned that the total repairs since this engine was started, apart from setting up the bushings, etc., done by the engine-room staff, have cost £50 12s. 6d. ($246).[1]

TABLE I. TRIPLE-EXPANSION PUMPING ENGINES, POWER CONSUMPTION AND COAL COSTS

Name	Engine and Pump Size (Cylinders in., Rams in., Stroke ft.)	Speed, R.P.M.	Indicated Horsepower	Water Horsepower	Mechanical Efficiency, Per Cent	Steam Pressure by Gage, Lb. per Sq.In.	Temperature, Deg. F.	Superheat, Deg. F.	Lb. Steam Used per Pump Displacement, Horsepower Hour	Steam, Lb. per W.Hp.-Hr., allowing 2½ Per Cent Slip	Per Cent Thermal Efficiency; W.Hp. Compared with Heat Expended	Vacuum, Inches of Mercury	Barometer, Inches of Mercury	Lb. Coal per W.Hp.-Hr. taking Boiler Efficiency at 65 Per Cent., Coal of 13,000 B.t.u. per Lb., allowing 20 Per Cent for General Station Losses and 10 Per Cent for Deterioration	Coal Cost per W.Hp.-Yr. of 300 12-Hr. Working Days with Coal at 40s. per Ton ($9.73) £ s. d.	Coal Cost per W.Hp.-Yr. of 300 20-Hr. Working Days with Coal at 40s. per Ton ($9.73) £ s. d.
1 Leeds City...	Cylinders. 15–25–40 Rams. (3) 13½ × 3	34	183.7	167.6	91.3	138	359	None	13.05	13.4	16.9	27.79	.....	2.34	7 10 0 ($36.50)	12 11 0 ($61.07)
2 Bristol.....	Cylinders. 16–28–46 Rams. (3) 18 × 3	27.5	184.6	167.9	91.0	160	370	None	12.28	12.58	17.96	.....	.....	2.21	7 2 0 ($34.55)	11 16 0 ($57.41)
3 Rosario.....	Cylinders. 15–25–40 Rams. (3) 16 × 3	36.0	232.0	209.0	90.0	177	431	52	12.28	12.6	17.4	28.0	29.7	2.26	7 5 0 ($35.28)	12 2 0 ($58.88)
4 Margate†....	Cylinders. 20–36–53 Rams. (3) 15½ × 4	23.3	264.0	242.0	91.0	160	393	22	11.64	12.0	18.6	.....	.....	2.13	6 17 0 ($33.34)	11 8 0 ($55.47)
5 Lincoln†....	Cylinders. 26–45–68 Rams. (3) 16½ × 4	20.0	385.0	345.0	90.0	170	535	160	10.97	11.2	18.7	.....	.....	2.12	6 16 0 ($33.09)	11 7 0 ($55.23)
6 Odessa.....	Cylinders. 20–36–54 Rams. (3) 17 × 3½	38.0	417.0	380.0	91.0	[illegible]	385	5	12.47	12.8	17.6	27.75	.....	2.25	7 5 0 ($35.28)	12 0 0 ($58.39)
7 Rand Water Board.....	Cylinders. 23–43–64 Rams (3) 12 × 3	37.5	502.0	461.0	91.8	182	500	120	11.0	11.33	18.8	22.67	25.24	2.11	6 16 0 ($33.09)	11 6 0 ($54.99)
8 Milwaukee...	Cylinders. 28–48–74 Rams. (3) 32 × 5	20.0	574.0	520.0	90.6	125	353	None	12.98	13.3	17.1	27.0	.....	2.31	7 8 0 ($36.01)	12 8 0 ($60.34)

† This engine also had bucket pumps, but for the purpose of these figures the whole load has been taken as if it had been on the ram pumps.
Cost in dollars has been based on standard rate of exchange, $4.866.

2. Running Costs—Of this cost the most important factor is coal, and in this respect the reciprocating engine again has the advantage. The pump plungers being directly coupled to the steam piston rods without the intervention of any gearing, the mechanical efficiency—that is, the horsepower measured in pump displacement, as compared with the indicated horsepower of the engine—is extremely high, upward of 90 per cent. A reference to the schedule, Tables I and II, of steam consumptions shows that within the limits specified these vary from 13 lb. to 11 lb. per pump horsepower-hour in water lifted by the reciprocating engine.

*Abstract from a paper, "Comparison Between Reciprocating Pumping Engines and Turbo-Driven Centrifugal Pumps," presented before the Conference of the Institution of Civil Engineers, London, England, June 29, 1921.

[1]Based on standard rate of exchange $4.866.

And these figures are inclusive of air and feed pumps; that is, they represent the whole consumption of the plant.

The examples quoted in Table I are all cases taken from actual practice. In arriving at these figures 2½ per cent. has been added for slip. The reciprocating engine also returns a considerable amount of heat to the boiler from its jacket and receiver drains, which is not the case with a steam turbine. And it will be noted that the thermal efficiencies given in Table II, which have been calculated on the water horsepowers, are uniformly high.

The figures of coal consumption have been calculated on the basis of an efficiency of 65 per cent for the steam-raising portion of the plant, 20 per cent has been added for general losses and a further 10 per cent for deterioration, so that the figures are, I believe, approximately reliable for actual water-works practice. Coal of a calorific value of 13,000 B.t.u. per lb. has been taken at a cost of 40s. ($9.73) per ton, and based on these figures the actual cost of a horsepower for a year of 300 twelve-hour days, and correspondingly for one of 300 twenty-hour days, has been calculated and is given in the schedules.

TABLE II. STEAM-TURBINE-DRIVEN CENTRIFUGAL PUMPS. CONSUMPTION AND COAL COSTS

Name	Size	Speed, R.P.M.	Water Horsepower	Steam Pressure by Gage, Lb. per Sq.In.	Temperature, Deg. F.	Superheat, Deg. F.	Lb. of Steam per W.Hp.-Hr.	Per Cent Thermal Efficiency; W.Hp. Compared with Heat Expended	Vacuum, Inches of Mercury	Barometer, Inches of Mercury	Lb. Coal per W.Hp.-Hr. taking Boiler Efficiency at 65 Per Cent.; Coal 13,000 B.t.u. Further allowing 20 Per Cent for General Station Losses and 15 Per Cent for Deterioration	Coal Cost per W.Hp.-Yr. of 300 12-Hr. Working Days with Coal at 40s. per Ton ($9.73)	Coal Cost per W.Hp.-Yr. of 300 20-Hr. Working Days with Coal at 40s. per Ton ($9.73)
1												£ s. d.	£ s. d.
Estimate	.....	4,500/800	144	180.0	480	100	19.3	10.8	28.50	30.0	3.84	12 6 0 ($59.85)	20 12 0 ($100.25)
2													
Bristol Trial—De Laval	14 in. Pump	10,500/750	260	149.4	366	None	20.34	10.82	27.85	30.05	3.814	12 4 0 ($59.37)	20 6 9 ($98.96)
3													
Ferry Lane Trial—De Laval	.....	10,500/748	276	150.0	459	93	18.38	11.62	28.0	29.5	3.56	11 8 9 ($55.65)	19 0 0 ($92.45)
4													
Estimate	.....	4,500/800	288	180.0	480	100	17.64	11.9	28.50	30.0	3.5	11 4 0 ($54.50)	18 16 0 ($91.48)
5													
Estimate	.....	4,500/700	[illegible]	180.0	480	100	17.1	12.2	28.50	30.0	3.39	10 17 4 ($52.88)	18 3 0 ($88.35)
6													
Battersea. Trial—Parsons-Gwynne	.....	6,000/1,500	470	195.0	556	170	16.7	12.16	28.0	.....	3.4	10 18 0 ($53.04)	18 4 0 ($88.56
7													
Estimate	.....	5,000/700	576	180.0	480	100	14.5	13.8	28.50	30.0	2.9	9 6 4 ($46.07)	15 10 8 ($75.58)

Turbine-Driven Pumps Less Efficient in Coal Consumption

In respect to coal consumption the turbine-driven pump is considerably less efficient. In the first place, the pump itself, when accurately made, in first-rate order and running under the exact conditions of head for which it was designed, has an efficiency of not more than 75 per cent., reduction gearing of, say, 94 per cent. to 96 per cent., while the hourly steam consumption of a turbine of sizes within the limits named and of first-rate construction such as would be suitable for high-class water-works plant, varies from about 10.5 lb. to 15 lb., giving an overall consumption per actual horsepower in water lifted of from, say, 14.5 lb. to 20.5 lb. It should also be remembered that while the efficiency of a reciprocating engine is nearly constant over a very large range, both in speed and head, that of the turbo-centrifugal plant falls considerably if, as is frequently necessary at water-works, the conditions of work are modified.

There is not as yet, so far as I am aware, the same prolonged experience in operating turbine-driven centrifugal pumps as is available in the case of the reciprocating type. I have prepared a schedule on the same lines for turbine-driven centrifugal pump as that for the reciprocating engine, and provided that the load is that for which the pump was designed, will, I believe, be found substantially accurate. It will be seen that the coal cost of a horsepower on the same basis of boiler efficiency as before, for a 300 twelve-hour-day year, would be from £9 6s. ($46.07) to £12 6s. ($59.85) as against £6 16s. ($33.10) to £7 10s. ($36.50) with a reciprocating engine, and for a 300 twenty-hour-day year, £15 10s. ($75.42) to £20 12s. ($100.25) as against £11 6s. ($54.99) to £12 11s. ($61.07) with the reciprocating type.

Executive Board of American Engineering Council to Meet in Washington

The next meeting of the executive board of the American Engineering Council of the Federated American Engineering Societies will be called to order by Vice-Chairman Calvert Townley on Sept. 30 at the Cosmos Club in Washington. The most important business coming before this meeting will be the election of a president to succeed Herbert Hoover, who resigned after he became Secretary of Commerce. Other items coming up for special consideration are plans for the Engineering Assembly, extension of Employment Service and the question of licensing and registration of engineers.

The Engineering Assembly Committee, consisting of A. P. Davis (chairman), Philip N. Moore, L. P. Alford, John C. Hoyt and F. A. Vaughn, will work out detailed plans for an assembly to be held in connection with the annual meeting of the American Engineering Council. Present plans are to make this assembly a three days' session to be held during the latter part of January. At least one day of the session will be devoted to the discussion of some special topic of interest to engineers in general, such as the elimination of waste, licensing of engineers or the National Department of Public Works.

In addition to the information summarized on pages 139 and 140 of the July 26 issue of *Power*, the Census Bureau has given out the following summary covering mine, quarry and well operations in the United States for 1919: Power used, 6,724,057 hp.; power increase over 1909, 45.9 per cent; cost of fuel and power in 1919. $122,095,769; increase in cost of fuel and power over 1909, 170.5 per cent. These figures relate to the operations of over 21,000 enterprises employing nearly a million wage earners and producing three and one-quarter billion dollars of products per year.

New Publications

GREAT LAKES, GENERAL RULES AND REGULATIONS PRESCRIBED BY THE BOARD OF SUPERVISING INSPECTORS.

The Steamboat Inspection Service of the Department of Commerce has issued this booklet of 160 pages covering the rules as amended at the board meeting of January, 1921. Considerable space is given to the requirements for marine boilers. In the back is a list of the instruments, machines and equipment approved for use on vessels.

Obituary

C. T. Berry, secretary, treasurer and general manager of the Oil City Boiler Works, Oil City, Pa., died on July 5, as the result of an automobile accident.

Personals

William M. Eader, Frederick, Md., has been appointed engineer in charge of the municipal electric-light plant and system.

R. K. Swift has resigned from the Ingersoll-Rand Co., after 8½ years as manager of the New England sales branch office and a previous ten years as salesman for that company.

William S. Murray, formerly chairman, and **Henry Flood, Jr.**, formerly engineer-secretary, of the Superpower Survey, have announced the formation of the firm of Murray & Flood with headquarters at the Grand Central Terminal, New York City.

Charles S. Crowell, Philadelphia manager of the Underfeed Stoker Co. of America, left that company's employ on July 1. Mr. Crowell has no definite plans for the future, but after a short vacation will remain actively in the combustion field.

H. C. Dickinson, who has been for some years chief of the automotive investigations division of the Bureau of Standards, has been granted a year's leave of absence from the bureau to become Director of Research of the Society of Automotive Engineers. He will, however, continue in some measure to co-operate in the Bureau of Standards investigations by giving a small amount of his time to conference and direction of the work of this division.

Gustav Clingwald has been appointed assistant superintendent of generation of the Southern California Edison Co. and will take charge of several hydro-electric stations belonging to the company. Mr. Clingwald has had extensive experience in hydro-electric work and has a number of inventions to his credit, including a long distance water-level indicator and an automatic water control for use with semi-automatic generating stations.

Society Affairs

The American Chemical Society will hold its fall meeting with the New York section, Tuesday, Sept. 6, to Saturday, Sept. 10. This will probably be the largest meeting of the society that has ever been held. Aside from the 2,500 members of the New York Section itself, many thousands are within a four or five hours' ride of New York. It is expected that three or four hundred British and Canadian members of the Society of Chemical Industry will be the guests of the American Chemical Society during the latter part of the week.

Business Items

The Everlasting Valve Co. has moved its general office, including the Sales Department, from 2 Rector St., New York City, to the new office at 49 Fisk St., Jersey City, N. J. The new office is at the manufacturing plant.

The Sullivan Machinery Co., Peoples Gas Bldg., Chicago, Ill., has moved its Cleveland office from 810 Park Bldg., to Room 824, Kirby Bldg. A supply depot and service station for coal-mining machinery, supplies and repair parts has been established at Seventh Ave. and 13th St., Terre Haute, Ind.

Trade Catalogs

The Pittsburgh Engineering Co., Jeanette, Pa., has issued its Catalog No. 5, describing and giving the list prices of cast-iron steam fittings, flanges and specialties.

The Providence Engineering Corporation, Providence, R. I., has issued a brief bulletin (G-90) entitled "Sargent Governors, Automatic Engine Stops and Synchronizers."

The Utility Safety Appliance Corporation, New York City, has issued a new bulletin entitled "Safeguarding Vertical Transportation," describing safety appliances for elevators.

The Walworth Manufacturing Co., Boston, Mass., has issued a series of 3¼ x 6¼-in. "envelope stuffers," each of which describes a brass valve for some particular purpose. The covers, decorated with bold "cubistic" designs in black, white and yellow, are strikingly original.

FUEL PRICES

BITUMINOUS COAL

The following table shows the trend of the spot steam market in various coals (mine-run basis, f.o.b. mines):

Coal	Market Quoting	July 26 1921	Aug. 2 1921
Pool 1,	New York	$3.15	$3.00@3.25
Pocahontas,	Columbus	3.15	3.00@3.25
Clearfield,	Boston	1.95	1.65@2.10
Somerset,	Boston	1.75	1.50@2.00
Pittsburgh,	Pittsburgh	2.10	2.00@2.15
Kanawha,	Columbus	2.15	1.75@2.25
Hocking,	Columbus	2.15	2.00@2.25
Pittsburgh No. 8	Cleveland	2.20	2.25@2.35
Franklin, Ill.,	Chicago	3.15	2.75@3.55
Central, Ill.,	Chicago	2.25	2.00@2.50
Ind. 4th vein,	Chicago	3.05	2.90@3.25
Standard,	St. Louis	1.70	1.65@7.75
West Ky.,	Louisville	2.30	2.00@2.65
Big Seam,	Birmingham	2.15	2.00@2.25
S. E. Ky.,	Louisville	2.20	2.25@2.40

New York—On Aug. 3, Port Arthur light oil, 22@25 deg. Baumé, 4½c. per gal. 30@35 deg., 5½c. per gal. f.o.b. Bayonne, N. J.

Chicago—July 23, for 24@28 deg. Baumé, 40@45c. per bbl.; 32@34 deg. 1¼@1½c. per gal. in tank cars f.o.b. Oklahoma refinery, or freight adjusted.

Pittsburgh—On Aug. 1, f.o.b. refinery; Pennsylvania, 36@40 deg., 3¼c. to 3½c. Oklahoma, 24@30 deg. 25c. per bbl., gas oil, 32@34 deg., 1⅜c. per gal., 36@38 deg., 1½c. 38@40 deg. 1⅝c.

St. Louis—July 30, prices f.o.b. cars, tank lots; 24@26 deg Baumé, 35c. per bbl.; 26@28 deg., 35c.; 28@30 deg. 40c.; 32@34 deg. 1⅜c. per gal.

Philadelphia—On Aug. 1, 26@28 deg. Baumé, Oklahoma, 50c. per bbl.; 30@34 deg., Oklahoma (group 3) 75c. per bbl.; 16@20 deg. Seaboard, 3½c. per gal.

Cincinnati—July 29, for 22@28 deg. Baumé, 6⅜c. per gal.

Cleveland—July 29, for 22@28 deg. Baumé, 5c. per gal.

New Construction

PROPOSED WORK

Mass., Boston—Harris, Forbes & Co., 35 Federal St., are having plans prepared for an 11 story, 70 x 80 ft. bank and office building on Federal St. About $400,000. Lockwood Green & Co., 209 Washington St., Archts.

R. I., Newport—The Bureau of Yards and Docks, Navy Dept., Wash., D. C., rejected bids received for the installation of refrigerating equipment at the Naval Hospital, here. Noted July 12.

N. Y., Brooklyn—The Bureau of Yards and Docks, Navy Dept., Wash., D. C., plans to install a 400 hp. boiler at Naval Hospital here. About $25,000. Spec. 4502.

N. Y., Iona Island—The Bureau of Yards and Docks, Navy Dept., Wash., D. C., received bids for power plant improvement at the Naval Ammunition Depot from Lord Constr. Co., 105 West 40th St., New York City, $20,939; Jaehnig & Peoples, 223 13th St., Newark, N. J., $22,683; J. R. Proctor, Inc., 120 Liberty St., New York City, $22,880. Spec. 4215.

N. Y., Long Island City—The Queens Realty Corp., c/o Neville & Bagge, Archts., 570 Bergen Ave., New York City, is having plans prepared for a 150 x 200 ft. apartment on Queens Blvd. and Lowery St. About $750,000.

N. Y., New York—Estate of E. Higgins, c/o B. W. Dorfman, Archt., 26 Court St., Brooklyn, will soon receive bids for a 3 story, 100 x 200 ft. store and office building on 134th St. between 8th and St. Nicholas Aves. About $300,000.

N. J., Kearney (Arlington P. O.)—The Bd. Educ. will receive bids until Aug. 15 for a high school. About $700,000. Guilbert & Bettelle, 2 Lombardy St., Newark, Archts. and Engrs.

N. J., Lake Denmark—The Bureau of Yards and Docks, Navy Dept., Wash., D. C., plans to make improvements to power plant and fire protection system. About $60,000. Spec. 4501.

N. J., Newark—The Bd. Educ., City Hall, Broad St., will receive bids about Sept. 15 for a school on Charlton Ave. About $250,000. Private plans.

N. J., Newark—H. Kruvant, 88 Rose Terrace, is having plans prepared for an 8 story apartment hotel on High and Clinton Sts. About $600,000. Bachoff, Jones & Cook, 9 Clinton St., Archts. and Engrs.

N. J., Newark—The Y. M. H. A. plans to build a Y. M. H. A. building on High and West Kinney Sts. About $400,000. F. Grad, 245 Springfield Ave., Archt. and Engr. Noted May 3.

Pa., Williamsport — M. E. Kilpatrick, Archt., 130 South 15th St., Philadelphia, will receive bids until Oct. 1 for a 5 story, 150 x 175 ft. Y. M. C. A. building on Elmira and 4th St. for the Y. M. C. A., c/o E. H. Davis, here. About $400,000.

Md., Annapolis — The Bureau of Yards and Docks, Navy Dept., Wash., D. C., plans to install a 150 hp. boiler at Naval Hospital here. About $16,000. Spec. 4500.

Md., Baltimore — The State Memorial Comn., Chamber of Commerce Bldg., plans to build a memorial building here. W. B. Wood, 816 Connecticut Ave., Washington, D. C., Archt. About $900,000.

D. C., Washington—Dept. of the Interior, F. M. Goodwin, Asst. Secy., will receive bids until Aug. 18 for the installation of four sets of stokers at the central power plant at Freedmen's Hospital here.

Va., Norfolk—Treasury Dept., J. A. Wetmore, Supervising Archt., Washington, D. C., will receive bids until Aug. 22 for several hospital buildings including a laundry building and boiler house for the United States Public Health Service Hospital at Tanners Creek.

Va., Yorktown—The Bureau of Yards and Docks, Navy Dept., Wash., D. C., plans to build a power house, dispensary and reservoir; also railroad siding here. About $136,000. Spec. 4498.

Fla., Orlando—J. Fange and associates are having plans prepared for a 10 story, 100 x 150 ft. hotel. About $1,000,000. M. S. King, Archt.

O., Cleveland—The Bd. Educ., East 6th St. and Rockwell Ave., will receive bids until Aug. 29 for a 3 story high school on East 116th St. and Corbett Ave., about $1,000,000; a 3 story grade school on Broadview and Spring Rds., about $500,000; one

on Diana and Darby Aves., about $500,000; one on East 116th St., about $400,000; also a 2 story addition to school on Rawlings Ave. and East 79th St., about $300,000. Steam heating systems will be installed in same. W. R. McCormack, East 6th St. and Rockwell Ave., Archt. Noted Feb. 15.

O., Cleveland—The Columbia Amusement Co., c/o J. Drew, 709 Euclid Ave., is having plans prepared for a 1 story theater including a steam heating system on East 18th St. and Euclid Ave. About $250,000. T. Lamb, 644 8th Ave., Archt.

O., Columbus—The Board of Trustees of the Ohio State University is having plans prepared for a 4 story commercial building, a 3 story, 60 x 100 ft. addition to Brown Hall, and a 2 story, 100 x 300 ft. addition to the power house; total about $840,000. J. N. Bradford, Ohio State University, Archt. Noted Jan. 11.

O., Columbus — The Thatcher Building Co., 501 James Bldg., is having plans prepared for a 7 story dormitory building on High St. About $500,000. A. J. Thatcher, Pres. Architect not announced.

O., East Cleveland—The Bd. Educ., C. E. Tilden, Dir. of Schs., 15144 Euclid Ave., plans to build a 3 story high school, including a steam heating system on Euclid Ave. opposite Grasmere Ave. About $450,000. Architect not selected.

O., Ravenna—The Bd. Educ. will receive bids Sept. 9 for a 2 story, 110 x 225 ft. high school. About $375,000. W. J. Dodge, Clk. O. D. Howard, 8 East Broad St., Columbus, Archt. Former bids rejected. Noted Jan. 18.

Ind., Brazil—The Bd. of Public Wks. plans to build a sewage disposal plant, including a pumping system, motors, etc. About $150,000. F. Dearmy, Clk.

Ind., Goshen—E. George plans to build a 4 story hotel, including a steam heating system. About $400,000. Architect not selected.

Ind., Indianapolis—Libby Realty Co., c/o Vonnegut, Bohn & Mueller, Archts., Indiana Trust Bldg., plans to build a 12 story office building at 2 N. Illinois St. About $750,000.

Ill., Rockford—The Bd. Educ., c/o E. E. Lewis, Supt., is having plans prepared for a 3 story junior high school, including a steam heating system. About $650,000. Peterson & Johnson, Swedish American Bank, Archts.

Wis., Kiel—Kiel Woodenware Co. is having plans prepared for the installation of additional equipment consisting of a 250 kw. generator unit, switchboard, boilers, etc. Cahill & Douglas, 217 West Water St., Milwaukee, Engrs.

Wis., Wausau—The D. L. Plumer Hospital, c/o A. P. Woodson, is having preliminary plans prepared for a 4 or 5 story hospital. About $300,000. E. R. Schmidt, Gardens & Martin, 104 South Michigan Ave., Chicago, Ill., Archts.

Ia., Des Moines—The Des Moines Water Co., C. Denman, Pres., 1001 Locust St., received bids July 28 for a 3 story, 103 x 120 ft. pump station and coal pit from A. H. Neumann Co., 519 Hubbell Bldg., $173,829. W. F. Kucharo, 622 Hubbell Bldg., $182,555. J. Maine & Sons, 119 8th St., $189,837.

Ia., Le Mars—The Sacred Heart Hospital Assn. will soon award the contract for a 4 story hospital, including a steam heating system on North Park St. About $290,000. W. L. Steele, United Bank Bldg., Sioux City, Archt.

Minn., Minneapolis—The MacPhail School of Music and Dramatic Arts, 804-6 Nicollet Ave., plans to build a 4 story school, including a steam heating system, on La Salle Ave. and 12th St. About $250,000. W. MacPhail, Pres. Architect not announced.

Mo., Hayti—The city, c/o J. H. Wilks, Mayor, will receive bids until Aug 18 for two 100 ft. deep wells, 2 triplex pumps, direct connected to 15 hp. oil engines, 3,000 ft., 4 x 6 cast iron pipe and a 30,000 gal. capacity, steel tank on 100 ft. steel tower. About $30,000. A. C. Moore, 1710 Murphy Bldg., Joplin, Engr.

Mo., St. Louis—The St. Charles Garage Co., c/o T. S. Kirkpatrick, 5510 Gates Ave., is having plans prepared for a 4 story, 130 x 160 ft. public garage, including a steam heating system on St. Charles and 11th St. About $350,000. N. B. Howard, Arcade Bldg., Archt.

Okla., Tulsa—The Bd. of Comrs., at office of City Auditor, will receive bids until Aug. 18 for filter units and equipment, settling basin, buildings, pump, etc. in connection with water works system. About $149,373.

Okla., Tulsa—H. Brockman plans to build a 10 story, 52 x 90 ft. hotel. About $324,000. Van Siclen & Edelvard, 3921 Detroit St., Archts.

Que., Montreal—V. Brosseau, 981 Drolet St., is in the market for one 20 hp. steam boiler.

Ont., Galt—The Galt Athletic Assn. will soon receive bids for a 200 x 280 ft. arena in the park, and will be in the market for complete refrigeration equipment. About $200,000. G. A. Bodley, Brantford, Archt.

Ont., Ridgetown—The Howard Township Council, G. McDonald, Clk., is having surveys made for an electric light and power distribution system. Mr. Lawlor, 190 University Ave., Toronto, Engr.

Ont., Walkerville—The School Board is having plans prepared for a school on Kildare Rd. About $450,000. Watt & Blackwell, Bank of Toronto, London, Archts.

CONTRACTS AWARDED

Mass., Cambridge — The Cambridge Gas Light Co., 719 Massachusetts Ave., has awarded the contract for alterations to boiler house to the New England Structural Co., 110 State St., Boston, and the installation of two 350 hp. steam boilers to Babcock Wilcox Co., East 3d St., Bayonne, N. J. Total cost about $70,000.

Mass., Somerville (Boston P. O.)—J. E. Locatelli, 78 Belmont St., will build a 4 story, 70 x 125 ft. theater, etc., on Highland and Central Aves., including a steam heating system. Owner will build by day labor.

R. I., Pawtucket—The Moore Fabric Co., Washington St., has awarded the contract for a 1 story boiler house to E. H. Bigney, 49 Weybosset St., Providence. About $8,000.

Conn., Ansonia—The Ansonia Electric Co., 55 Main St., has awarded the contract for a 2 story, 60 x 200 ft. factory to Aberthaw Constr. Co., 27 School St., Boston, Mass. About $250,000.

Conn., Hartford—The Health & Charity Dept. has awarded the contract for a 2 story, 43 x 63 ft. central heating plant and laundry, two concrete tunnels and coal bunker on Holcomb St. to G. Cudemo, 327 Trumbull St. About $80,000. Noted July 26.

N. Y., Cortland—The Comn. of Educ., F. B. Gilbert, has awarded the contract for a heating system to be installed in the new Normal School here to E. J. Bates Co., 228 West Water St., Syracuse, N. Y., $103,358.

N. Y., New York—The Bar Assn., c/o H. C. Severance, Archt., 372 Lexington Ave., has awarded the contract for a 16 story office building on West 44th St. to C. L. Fraser, 372 Lexington Ave. About $750,000. Noted March 22.

N. Y., New York—The U. S. Mortgage & Trust Co., Madison Ave., has awarded the contract for a 2 story bank bldg., on Madison Ave. and 74th St., to Clough Bourne Constr. Co., 101 Park Ave. About $500,000. Noted May 23.

Pa., Philadelphia—A. T. Abbott & Co., Berkley Ave., has awarded the contract for a 5 story, 73 x 170 ft. textile mill at 23d St. and Allegheny Ave. to J. N. Gill & Co., Otis Bldg.

Pa., Philadelphia—The city has awarded the contract for furnishing and erecting motor driven pumps at Roxborough Booster pumping station to Dravo, Doyle Co., Commercial Trust Bldg., $19,000; furnishing and installing traveling grate stokers for Queen Lane & Shawmut pumping stations to Combustion Eng. Corp., 43 Broad St., New York City, $41,534; 1 fuel economizer and motor driven fans for Torresdale pump station; 1 fuel economizer for Shawmut also 2 for Larners Point station to B. F. Sturtevant Co., 135 West 3d St., $32,000 and $20,000, respectively; coal handling equipment for Torresdale pumping station to Specialty Eng. Co., Penna. Bldg., $13,945.

Pa., Philadelphia—The city has awarded the contract for 2 boilers each 150 hp. to be installed at the Mingo Creek Station to the Coatesville Boiler Wks., $12,000.

Pa., Philadelphia—The Hurley Motor Co., 219 N. Broad St., will build a 10 story, 80 x 100 ft. sales and service station. Contract was awarded to W. Steele & Sons, Engineers, 16th and Arch Sts. About $300,000.

N. C., Raleigh — The North Carolina State Hospital has awarded the contract for the construction of various buildings also additions, alterations, remodeling, etc., to J. E. Beaman, Commercial Bank Bldg., $600,000. Noted April 5.

O., Xenia—The Bd. Educ. has awarded the contract for a 2 story, 128 x 250 ft. high school on Church St. to the Industrial Building Co., 757 Reibold Bldg., Dayton, $283,000. Noted April 26.

Mich., Flint—The Union School Dist. has awarded the contract for building two 2 story schools, one on Arlington St. and one on Civic Park Site to E. W. Wood Co., 1805 Ford Bldg., Detroit. About $250,000 and $240,000 respectively. Steam heating system, mechanical ventilation, Plenum system will be installed.

Wis., Janesville — The Bd. Educ. has awarded the contract for a 3 story, 180 x 210 ft. high school and a 40 x 50 ft. boiler house on South Main St. to J. P. Cullen & Sons, Water St., $513,813. Noted June 28.

Minn., Virginia — The Bd. Educ. has awarded the contract for a 3 story school on 3d St. to Nauffts & Bergstrom, 416 Columbia Bldg., Duluth. About $218,900. A steam heating system will be installed.

S. D., Watertown—The city has awarded the contract for furnishing and installing equipment for municipal electric light and power plant including a 750 k.v.a. generator, one Northbury engine and auxiliary equipment to J. G. Robertson, 2542 University Ave., St. Paul, Minn. About $50,000. Noted May 11.

S. D., Redfield—The city has awarded the contract for a reservoir with capacity of 1,000,000 gal. and a pumping building to H. F. Stolte, $34,985. Noted July 5.

Mo., Clinton—A. W. Vanderford has awarded the contract for a 1 story refrigerator plant near Weaubleau to the United Iron Wks., 625 Kentucky St., Joplin, $10,000.

Ont., Hamilton — The Bd. Educ., R. H. Foster, Secy., has awarded the contract for the construction of a 4 story technical school on Wentworth St. to W. E. Wood Constr. Co., 87 Sandwich St., Dalkerville; electric lighting to the Electric Supply Co., 65 James St. S., and the ventilating, heating, etc., to A. Clark, 7 Main St. W. Total cost about $700,000. Noted Jan. 4.

Ont., Saulte Ste Marie—The Bd. Educ. J. T. Later, Secy., has awarded the contract for a 3 story, 120 x 138 ft. technical school on Tancred and Wellington Sts., to Mitchell & Cooper, Adams Block, $225,000. Steam heating and mechanical ventilating systems will be installed. Noted June 7.

Machinery—Employment—Business Opportunities

SEARCHLIGHT SECTION

See pages 46 to 52

PRICES - MATERIALS - SUPPLIES

Electrical prices on following page are prices to the power plant by jobbers in the larger buying centers east of the Mississippi. Elsewhere the prices will be modified by increased freight charges and by local conditions.

POWER-PLANT SUPPLIES

HOSE—

	Fire	50-Ft. Lengths
Underwriters' 2½-in.		53c. per ft.
Common, 2½-in.		60–5%

	Air		
	First Grade	Second Grade	Third Grade
¾-in. per ft.	$0.33	$0.23	$0.15

Steam—Discounts from List

First grade... 40–10% Second grade.....50–5% Third grade..60–5%

RUBBER BELTING—The following discounts from list apply to transmission rubber and duck belting:

Competition..... 70-5% Best grade..... 50-10–5%
Standard..... 65-5%

LEATHER BELTING—Present discounts from list in fair quantities (½ doz. rolls):

Light Grade	Medium Grade	Heavy Grade
50–5%	45%	40%

RAWHIDE LACING { For cut, best grade, 50–10%, 2nd grade, 60%. For laces in sides, best, 41c per sq. ft.; 2nd, 39c. Semi-tanned: cut, 50%; sides, 43c per sq. ft.

PACKING—Prices per pound:

Rubber and duck for low-pressure steam	$1.00
Asbestos for high-pressure steam	2.00
Duck and rubber for piston packing	1.00
Flax, regular	1.20
Flax, waterproofed	1.70
Compressed asbestos sheet	1.00
Wire insertion asbestos sheet	1.50
Rubber sheet	.45
Rubber sheet, wire insertion	.70
Rubber sheet, duck insertion	.50
Rubber sheet, cloth insertion	.30
Asbestos packing, twisted or braided and graphited, for valve stems and stuffing boxes	1.25
Asbestos wick, ½- and 1-lb. balls	.75

PIPE AND BOILER COVERING—Below are part of standard lists, with discounts.

PIPE COVERING		BLOCKS AND SHEETS	
Pipe Size	Standard List Per Lin.Ft.	Thickness	Price per Sq.Ft.
1-in.	$0.27	½-in.	$0.27
2-in.	.36	1 -in.	.30
6-in.	.80	1½-in.	.45
4-in.	.60	2 -in.	.60
5-in.	.45	2½-in.	.75
8-in.	1.10	3 -in.	.90
10-in.	1.30	3½-in.	1.05

85% magnesia high pressure..... 25% off

For low-pressure heating and return lines { 4-ply..... 50% off; 3-ply..... 52% off; 2-ply..... 54% off

PORTLAND CEMENT—New York, $2.60@2.70 without bags, in cargo lots delivered on job. Bag charge of 40c. per bbl.

STRUCTURAL STEEL—New York delivered price, 3 to 15-in. beams and channels and 3 to 6-in. angles, tees, and plates, all $2.88 per 100 lb.

COTTON WASTE—The following prices are in cents per pound:

	New York			
	Current		Cleveland	Chicago
White	7.50@10.00		12.00	14 25
Colored mixed	5.50@ 9.00		9.00	12.00

WIPING CLOTHS—Jobbers' price per 1000 is as follows:

	13½ x 13½	13½ x 20½
Cleveland	$55.00	$65.00
Chicago	41.00	43.50

LINSEED OIL—These prices are per gallon:

	New York	Cleveland	Chicago
Raw in barrels (5 bbl. lots)	$0.80	$0.86	$0.75

WHITE AND RED LEAD—Base price per pound:

	Red				White	
	Current		1 Year Ago		Current	1 Yr. Ago
	Dry	In Oil	Dry	In Oil	Dry and In Oil	Dry and In Oil
100-lb. keg	12.25	13.75	15.50	17.00	12.25	15.50
25- and 50-lb. kegs	12.50	14.00	15.75	17.25	12.50	15.75
12½-lb. keg	12.75	14.25	16.00	17.50	12.75	16.00
1-lb. cans	15.25	16.75	18.50	20.00	15.25	18.50
5-lb. cans	17.25	18.75	20.50	22.00	17.25	20.50

RIVETS—The following quotations are allowed for fair-sized orders from warehouse:

	New York	Cleveland	Chicago
Steel ½ and smaller	50–10%	60–10%	45%
Tinned	50–10%	60–10%	30%

Structural rivets, ½, ¾, 1 in. diameter by 2 in. to 5 in. sell as follows per 100 lb.:

New York.....$4.40 Chicago.....$4.53 Pittsburgh.....$2.65

Boiler rivets, same sizes:

New York.....$4.50 Chicago.....$4.63 Pittsburgh.....$2.75

REFRACTORIES—Prices in carlots:

Chrome brick, eastern Shipping points	net ton	60@ 65
Chrome cement, 40@45% Cr_2O_3	net ton	30@ 35
Chrome cement, 40@45% Cr_2O_3, in sacks	net ton	33@ 38
Clay brick, 1st quality, fire clay, 9-in. shapes, Pennsylvania, Ohio and Kentucky	per 1000	55@ 60
Clay brick, 2d quality, fire clay, 9-in. shapes Pennsylvania, Ohio and Kentucky	per 1000	45@ 50
Magnesite brick: 9-in. straight	net ton	70@ 75
Magnesite brick: 9-in. arches, wedges and keys	net ton	77@ 82
Magnesite brick: Soaps and splits	net ton	98@ 105
Silica brick: Chicago district	per 1000	40@ 45
Silica brick: Birmingham, Ala	per 1000	38@ 42
Silica brick: Mt. Union, Pa	per 1000	35@ 40
Magnesite cement: Eastern shipping point, in bags	net ton	50@ 55
Magnesite cement: Eastern shipping point, in bags	net ton	47@ 52

BABBITT METAL—Warehouse prices in cents per pound:

	New York	Cleveland	Chicago
Best grade	70.00	38.50	35.00
Commercial	30.00	13.50	9.00

COLD FINISHED STEEL—Warehouse prices are as follows:

	New York	Chicago	Cleveland
Round shafting or screw stock, per 100 lb. base	$4.43	$4.63	$4.00
Flats, square and hexagons, per 100 lb. base	4.93	4.63	4.50

BOILER SPECIALTIES—F. o. b. New York or Jersey City, discounts on list:

	Current
Copper ferrules	75%
Boiler flanges	55%
Boiler lugs	Net list
Boiler stay bolts	60%
Boiler patch bolts	Net list
Boiler fitting-up bolts	45%
Pressed steel boiler lugs	Net list
Pressed steel boiler hangers	Net list

WROUGHT PIPE—The following discounts are to jobbers for carload lots on the Pittsburgh basing card of July 7, 1921:

BUTT WELD

Steel Black	Galv.	Inches	Iron Black	Galv.
1 to 3..... 64½	52	⅛ to 1¼.....	39½	24½

LAP WELD

2.....	56½	44	15.....	42½ 32
2½ to 6.....	60½	48	2.....	34½ 20½
7 to 12.....	57½	44	2½ to 6.....	37½ 24½
13 and 14.....	45	37	7 to 12.....	35½ 22½

BUTT WELD, EXTRA STRONG, PLAIN ENDS

1 to 1½.....	62½	51	1 to 1½.....	39½ 25½
2 to 3.....	63½	52		

LAP WELD, EXTRA STRONG, PLAIN ENDS

2.....	54½	43	2.....	35½ 22½
2½ to 4.....	58½	47	2½ to 4.....	38½ 26½
4½ to 6.....	57½	46	4½ to 6.....	37½ 25½
7 to 8.....	53½	40	7 to 8.....	30½ 18½
9 to 12.....	48½	35	9 to 12.....	25½ 13½

BOILER TUBES—Following are prices in New York warehouse of tubes manufactured according to specifications of the American Society of Mechanical Engineers:

Size	Lapweld Steel	C. C. Iron	Seamless Steel
1	.....	.....	$0.22
1¼	.....	.....	.21
1½	.....	.....	.19
1¾	$0.2332	$0.2855	.24
2	.1848	.22	.20
2¼	.2112	.2514	.22
2½	.2220	.2955	.26
2¾	.2516	.3349	.30
3	.2812	.3743	.33
3¼	.3330	.4320	.32
3½	.3264	.4608	.34
4	.4148	.5856	.43

Tubes 2½ in. diameter, or smaller, over 18 ft. long, 10 per cent extra.

These prices are net per lineal foot based on stock lengths. If cut to special lengths, billing will be based on the entire stock lengths.

In addition to the above, standard cutting charges are as follows:

1¼ in. to 2 in. diameter, 5c. per cut. 2½ in. diameter, 7c. per cut
2¾ in. diameter, 6c. per cut. 3 in. diameter, 9c. per cut
3½ in. to 4 in. diameter, 10c.

ELECTRICAL SUPPLIES

ARMORED CABLE—

B. & S. Size	Two Cond. M Ft.	Three Cond. M Ft.	Two Cond. Lead M Ft.	Three Cond. Lead M Ft.
No. 14 solid	$ 46.50(net)	$138.00	$164.00	$210.00
No. 12 solid	135.00	170.00	225.00	265.00
No. 10 solid	185.00	235.00	275.00	325.00
No. 8 stranded	285.00	375.00	520.00	500.00
No. 6 stranded	400.00	500.00	560.00	.....

From the above lists discounts are:

Less than coil lots	15%	10%
Coils to 1,000 ft.	25%	20%
1,000 ft. and over	35%	25%

BATTERIES, DRY—Regular No. 6 size red seal, Columbia, or Ever-Ready:

	Each, Net
Less than 12	$0.40
12 to 50	.34
50 to 125 (bbl.)	.30½
125 (bbl.) or over	.29

CONDUIT, Price per 1,000 ft.; ELBOWS AND COUPLINGS, Per 100 pieces, f. o. b. New York, with 10-day discount of 5 per cent.

	Conduit		Elbows		Couplings	
Size, In.	Black 2,500 to 5,000 Lbs.	Galvanized 2,500 to 5,000 Lbs.	Black 2,500 to 5,000 Lbs.	Galvanized 2,500 to 5,000 Lbs.	Black 2,500 to 5,000 Lbs.	Galvanized 2,500 to 5,000 Lbs.
⅜	$64.43	$69.53	$15.35	$16.49	$5.85	$6.08
½	83.72	90.62	20.20	21.70	8.08	8.68
¾	120.36	130.56	29.99	32.12	10.50	11.28
1	162.84	176.54	38.61	41.31	14.59	15.61
1¼	194.70	211.20	51.48	55.08	18.02	19.28
1½	261.96	284.16	94.38	100.98	24.02	25.70
2	414.18	449.28	154.44	165.24	34.32	36.72
2½	541.62	587.52	411.84	440.64	51.48	55.80
3	678.96	734.16	909.48	973.08	68.64	73.40
3½	826.22	891.62	1,051.05	1,124.55	85.80	91.80

CONDUIT NON-METALLIC, LOOM—

Size I. D., In.	Feet per Coil	List, Ft.
⅜	250	$0.05½
½	250	.06
¾	250	.09
1	200	.12
1¼	200	.15
1½	150	.18
2	100	.25
2½	100	.33
3	Odd lengths	.40
4	Odd lengths	55

1000 ft. and over.... 60%
Coils..... 50%
Less coils, 40%

CUT-OUTS—Following are net prices each in standard-package quantities:

CUT-OUTS, PLUG

S. P. M. L.	$0.10	D. P. D. B.	$0.38
D. P. M. L.	.18	T. P. to D. P. S. B.	.23
T. P. M. L.	.28	T. P. S. B.	.34
D. P. S. B.	.20	T. P. D. B.	.55

CUT-OUTS, N. E. C. FUSE

	0-30 Amp.	31-60 Amp.	60-100 Amp.
D. P. M. L.	$0.45	$1.15	$1.45
T. P. M. L.	.63	1.60	2.15
D. P. S. B.	.57	1.45	.....
T. P. S. B.	1.04	2.10	.....
D. P. D. B.	.99	2.65	.....
T. P. D. B.	1.70	4.80	.....
T. P. to D. P. D. B.	1.15	3.40	.....

FLEXIBLE CORD—Price per 1,000 ft. in coils of 250 ft.:

No. 18 cotton twisted	$13.05
No. 16 cotton twisted	16.25
No. 18 cotton parallel	15.75
No. 16 cotton parallel	19.50
No. 18 cotton reinforced heavy	23.40
No. 16 cotton reinforced heavy	26.80
No. 18 cotton reinforced light	19.30
No. 16 cotton reinforced light	22.50
No. 18 cotton Canvasite cord	16.35
No. 16 cotton Canvasite cord	19.50

FUSES, ENCLOSED—

250-Volt	Std. Pkg.	List	600-Volt	Std. Pkg.	List
3-amp. to 30-amp.,	100	$0.25	3-amp. to 30-amp.,	100	$0.40
35-amp. to 60-amp.,	100	035	35-amp. to 60-amp.,	100	.60
65-amp. to 100-amp.,	50	.90	65-amp. to 100-amp.,	50	1.50
110-amp. to 200-amp.,	25	2.00	110-amp. to 200-amp.,	25	2.50
225-amp. to 400-amp.,	25	3.60	225-amp. to 400-amp.,	25	5.50
425-amp. to 600-amp.,	10	5.50	450-amp. to 600-amp.,	10	8.00

Discount: Less 1-5th standard package, 40%; 1-5th to standard package, 45%; standard package, 50%.

RENEWABLE FUSES, ENCLOSED—

Sizes	250-Volt List-Price	600-Volt List-Price	Std. Pkg. Quantity	Carton Quantity
1 to 30-amp.	$0.50 ea.	$1.10 ea.	100	10
35 to 60-amp.	1.00 ea.	1.25 ea.	100	10
65 to 100-amp.	2.00 ea.	3.00 ea.	50	5
110 to 200-amp.	4.00 ea.	5.00 ea.	25	5
225 to 400-amp.	7.50 ea.	11.00 ea.	25	1
450 to 600-amp.	11.00 ea.	16.00 ea.	10	1
450 to 600-amp.	11.00 ea.	16.00 ea.	10	1

RENEWAL LINE FOR ABOVE FUSES—

1 to 30	$0.30 ea.	$0.05	100	100
35 to 60	.05 ea.	.06	100	100
65 to 100	.10 ea.	.10	50	50
110 to 200	.15 ea.	.15	25	50
225 to 400	.30 ea.	.30	25	25
450 to 600	.60 ea.	.60	10	10

Discount Without Contract—Fuses:
Broken carton 5%
Unbroken carton but less than std. pkg. 22%
Std. pkg. 40%
Discount Without Contract—Renewals:
Less than std. pkg. ..... Net list
Standard package 40%
Discount With Contract—Fuses:
Broken cartons 10%
Unbroken cartons but less than standard package 26%
Standard package 42%
Discount With Contract—Renewals:
Less standard package ..... Net list
Standard package 42%

FUSE PLUGS, MICA CAP—

0-30 ampere, standard package	$3.75
0-30 ampere, less than standard package	4.25

LAMPS—Below are present quotations in less than standard package quantities:

Straight-Side Bulbs Mazda B—				Pear-Shaped Bulbs Mazda C—			
Watts	Plain	Frosted	No. in Package	Watts	Clear	Frosted	No. in Package
10	$0.40	$0.45	100	75	$0.75	$0.80	50
15	.40	.45	100	100	1.10	1.20	24
25	.40	.45	100	150	1.55	1.65	24
40	.40	.45	100	200	2.10	2.25	24
50	.40	.45	100	300	3.15	3.35	24
60	.45	.50	100				12
				500	4.60	4.85	12
				750	6.50	6.85	8
				1,000	7.50	7.85	8

Standard quantities are subject to discount of 10% from list. Annual contracts ranging from $150 to $300,000 net allow a discount of 17 to 40% from list.

PLUGS, ATTACHMENT—

	Each
Porcelain separable attachment plug	$0.24
Composition 2-piece attachment plug	.32
Swivel attachment plug	.16
Current taps	.40

RUBBER-COVERED COPPER WIRE—Per 1000 ft. f. o. b. New York.

No.	Solid Single Braid	Solid Double Braid	Stranded, Double Braid	Duplex
14	$ 6.30	$ 8.10	$9.55	$15.65
12	8.25	10.20	11.95	19.70
10	10.95	13.00	15.20	25.50
8	14.75	17.00	20.10	34.00
6	.....	.....	30.45	.....
4	.....	.....	41.00	.....
2	.....	.....	60.50	.....
1	.....	.....	80.95	.....
0	.....	.....	95.70	.....
00	.....	.....	113.90	.....
000	.....	.....	136.65	.....
0000	.....	.....	165.85	.....

SOCKETS, BRASS SHELL—

½ In. or Pendant Cap			¾ In. Cap		
Key Each	Keyless Each	Pull Each	Key Each	Keyless Each	Pull Each
$0.33	$0.30	$0.50	$0.39	$0.36	$0.56

Less 1-5th standard package ..... +25%
1-5th to standard package ..... List
Standard package 20%

WIRE, ANNUNCIATOR AND DAMPPROOF OFFICE—

No. 18 B. & S. regular spools (approx. 8 lb.)	33c. lb.
No. 18 B. & S. regular 1-lb. coils	34c. lb.

WIRING SUPPLIES—

Friction tape, ¾ in., less 100 lb. 37c. lb., 100 lb. lots	35c. lb.
Rubber tape, ¾ in., less 100 lb. 37c. lb., 100 lb. lots	35c. lb.
Wire solder, less 100 lb. 30c. lb., 100 lb. lots	25c. lb.
Soldering paste, 2 oz. cans	$1.50 doz.

SWITCHES, KNIFE—

TYPE "C" NOT FUSIBLE

Size, Amp.	Single Pole, Each	Double Pole, Each	Three Pole, Each	Four Pole, Each
30	$0.42	$0.68	$1.02	$1.36
60	.74	1.22	1.84	2.44
100	1.50	2.50	3.76	5.00
200	2.70	4.50	6.76	9.00
	TYPE "C" FUSIBLE, TOP OR BOTTOM			
30	.70	1.06	1.60	2.12
60	1.18	1.80	2.70	3.60
100	2.38	3.66	5.50	7.30
200	4.40	6.76	10.14	13.50

Discounts:

Less than $10.00 list value	15%
$10 to $25 list value	net list
$25 to $50 list value	5%
$50 to $200 list value	20%
$200 list value or over	25%